

Injury

Sally K. Stansfield, Gordon S. Smith, and William P. McGreevey

Injuries are too often referred to as “accidents,” suggesting that such events are random and have causes not within our control. On the contrary, injuries occur with definable patterns which help to identify risk factors and thereby imply strategies for prevention. Injury control, including reduction of the frequency, severity, and consequences of injury, can reduce the growing burden of injury in the developing world (Smith and Barss 1991). Already one of every four to nine persons suffers a disabling injury each year in developing countries, and it is estimated that 2 percent of the world’s population is currently disabled as a result of injury (WHO 1986).

In developing countries, injury is frequently viewed as an inevitable consequence of technological change and economic development. In the view of both business and the community, short-term economic gains often outweigh the cost of death and disability from injury. Because they are socioeconomically and politically disadvantaged, people in developing countries live daily with a risk of injury which would be unacceptable in industrial nations. As emphasized in the recently adopted “Manifesto for Safe Communities,” this “inequality in the safety status of an individual in developing and developed countries is of concern to all countries” (WHO 1989a, p. 7).

The heterogeneity of the mechanisms and effects of injury has interfered with awareness of its public health importance and thereby hampered the development of comprehensive programs to address this important health problem. Yet as injury emerges as the leading cause of death in more and more countries, there is a growing demand for the development of national and international programs for injury control.

Definitions

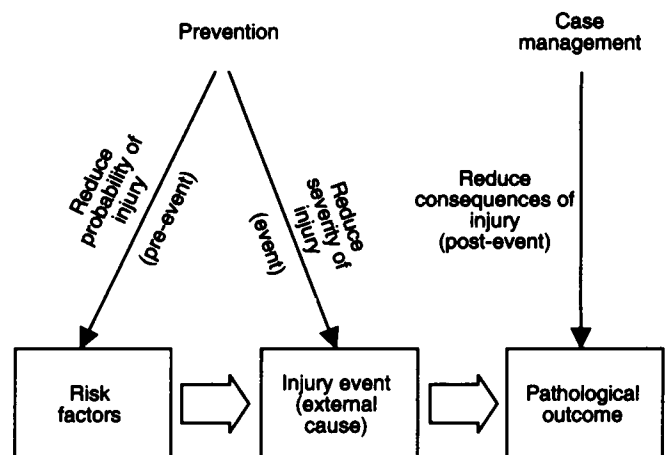
Physical injury is caused by an acute exposure to damaging energy (mechanical, electrical, thermal, or chemical) or by the sudden absence of essentials (such as the lack of oxygen in drowning, or heat in hypothermic injury). The study of injury focuses on the acute effects and long-term disability resulting from the acute injury; therefore it does not include delayed or indirect effects of chronic exposure, such as those from carcinogenic chemicals (Waller 1985; Robertson 1992). Important,

though often neglected, are the “adverse psychological and social consequences” (WHO 1989a, p. 5) of such injurious events as rape or child abuse.

It is important to distinguish the “pathological outcome” of an injurious event from its mechanism, or “external cause.” Figure 25-1 is a schematic drawing of the chain of events of injuries; the drawing also emphasizes that opportunities for *prevention* of injury depend on (a) reduction of the probability of an injurious event (through risk reduction) and (b) reduction of the severity of injury (through alteration of the nature of the event). In contrast, *case management* depends on (c) reduction of the consequences of the injury (through altering the pathological outcome) once that injury has occurred. Haddon (1980) referred to these three “phases” of injury control as “pre-event,” “event,” and “post-event.”

Injuries are categorized by both their *external cause* (E-codes, which describe the injurious event) and by their *pathological outcome* (N-codes, which describe the nature of the injury) in the WHO *International Classification of Diseases* (WHO 1977). In table 25-1 we list the pathological outcomes most commonly associated with selected injurious events (external causes).

Figure 25-1. Chain of Injury Events and Opportunities for Injury Control



Source: Authors' data.

Table 25-1. Pathological Outcomes Commonly Associated with Injury Events in the Developing World

Injury event	Pathological outcome	
	Type of injury	Infectious complications
Fire	Burn and thermal injury	Yes
	Anoxic injury	Yes
Electric shock	Burn and thermal injury	Yes
Collision	Crush and deceleration injury	Yes
	Abrasion and laceration	
	Dislocation and fracture	
Fall	Crush and deceleration injury	Yes
	Abrasion and laceration	
	Dislocation and fracture	
Assault	Abrasion and laceration	Yes
	Dislocation and fracture	
	Anoxic injury	
Submersion (drowning)	Anoxic injury	Yes
Poisoning	Toxic injury	No

Source: Authors' data.

Different preventive strategies are also implied by the further categorization of the external cause of injury as *unintentional* or *intentional* (homicide, other assaults, and suicide). Reflecting the increasing recognition of the preventability of injury, the term "unintentional injury" has been preferred to "accidents" (Langley 1988).

Risk Factors

Just as specific pathological outcomes are seen more commonly with certain injurious events, each injurious event is commonly associated with specific risk factors. Some of the main risk factors for the injurious events prevalent in developing countries are shown in table 25-2. The importance of each of these risk factors varies, however, for each external cause of

injury and according to local patterns of transport and of domestic and occupational activities.

Demographic characteristics which are determinants of exposure to risk of injury include gender, age, occupation, and socioeconomic status. The behavior patterns of males place them at higher risk for most injuries (burns are one of the exceptions; see Taket 1986), and there is a trend of increasing difference between males and females with increasing age. Infanticidal deaths are, however, more common among female children.

Adolescents and younger adults, who already sustain more injuries than others, further increase that risk with alcohol use. For example, persons between the ages of sixteen and twenty-four drive approximately 20 percent of the total vehicle miles traveled in the United States, yet they account for 42 percent of the alcohol-related fatalities (NHTSA 1988). Although there is less such information from developing countries, it appears that the patterns are similar (Wyatt 1980; Sinha, Sengupta, and Purohit 1981). Age also affects the case-fatality ratio, or the risk of mortality once an injury has been sustained, with increased mortality observed among both the very young and the very old (Waller 1985; Baker and others 1992).

The poor suffer disproportionately from homicide, assault, pedestrian fatality, and burn injury fatality. The death rate from unintentional injury is also twice as high in low-income areas as in high-income areas of the United States (NRC/IOM 1985). Similar patterns are evident in developing countries, especially in poor urban areas. The demands of economically and politically underprivileged groups for safe products, working environments, and communities are less likely to meet with success. Psychologic disorders, such as substance abuse, violence (toward both self and others), isolation or withdrawal, and depression, are also more commonly found among populations marginalized by poverty. These disorders, along with the risky behaviors associated with lack of safety education, all predispose people to injury.

In addition to affecting people's exposure to risk of injury, socioeconomic status often alters the case-fatality ratio once the injury occurs (Baker, O'Neill, and Karpe 1984), in part because of variation in access to definitive surgical care. In

Table 25-2. Selected Risk Factors Associated with Events in the Developing World

Risk factor	Injury event						
	Fire	Electric shock	Collision	Fall	Assault	Submersion (drowning)	Poisoning
Male sex	No	Yes	Yes	Yes	Yes	Yes	No
Age							
Under 15	Yes	No	No	Yes	No	Yes	Yes
15-64	No	Yes	Yes	No	Yes	No	Yes
65 or older	No	No	No	Yes	No	No	No
Low socioeconomic status	Yes	No	No	No	Yes	No	No
Hazardous products	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Alcohol use	Yes	No	Yes	Yes	Yes	Yes	Yes
Psychologic disorders	Yes	No	No	Yes	Yes	Yes	Yes
Poor safety education	Yes	Yes	Yes	Yes	No	Yes	Yes

Source: Authors' data.

lower socioeconomic groups both the children (who are often poorly supervised) and their parents (who must often take greater occupational risks) have a higher frequency of both fatal and nonfatal injury. In their study of an urban slum in Rio de Janeiro, Reichenheim and Harpham (1989) found an association between children's injury and maternal marital status, maternal stress or depression, and mothers' work outside the home.

Among the substance abuse disorders, alcohol consumption represents the main avoidable risk for injury. In the United States, alcohol-related mortality (ARM) accounts for 4.5 percent of deaths from all causes (CDC 1990). Unintentional injury accounts for 28.7 percent of all ARM and more than half of all years of potential life lost (YPLL) before age sixty-five. Intentional injury accounts for 16.8 percent of all ARM and 29.1 percent of all YPLL before age sixty-five. Of fatally injured motor vehicle drivers in 1987, 38 percent were intoxicated (blood alcohol concentration greater than 0.10 percent), a decline from 44 percent in 1982 (NHTSA 1988).

Like the other lifestyle features which accompany economic development, alcohol abuse and its adverse health effects are beginning to be recognized for their importance in developing countries (Edwards 1979). Although the per capita consumption of alcohol in industrial countries has decreased or at least remained stable, it is clearly on the increase in most of the developing world. The total availability of alcoholic beverages in developing countries has increased by 146 percent since the early 1960s (Kortteinen 1988). Per capita consumption and the fraction of annual income spent on alcohol have both increased each year since 1978 in Singapore (Curry 1989).

Even more dramatic are the data from the rural Kisii District of Kenya, where Bittah, Owola, and Oduor (1979) documented that up to 27 percent of randomly selected males and 24 percent of females met the WHO criteria (WHO 1952) for alcoholism. Nearly half of male and one-quarter of female heads of households in a Nairobi slum have been categorized as alcoholics (Nielsen, Resnick, and Acuda 1989). In addition to predisposition to alcohol-related disease and mortality, including that from injury, these families are characterized by worsening economic status, higher rates of separation and divorce, other psychiatric disorders, and premature mortality among both the adults and their children.

The role of alcohol and other drug use in predisposing people to injury in the developing world is also only beginning to be documented (Patel and Bhagwatt 1977; Jacobs and Sayer 1983). In addition to limited awareness among health and law enforcement professionals of alcohol as a risk factor, the lack of technology for blood or breath alcohol measurements is a constraint to further definition of the problem (Ryan 1990). In Papua New Guinea, where a few studies have been conducted, one-third to more than half of fatally injured drivers were found to be legally intoxicated, and 69 to 90 percent of fatally injured pedestrians were found to have blood alcohol levels above 80 milligrams per 100 milliliters (Wyatt 1980; Sinha, Sengupta, and Purohit 1981).

Although there are few studies even in industrial countries, alcohol is also a risk factor for nonvehicular injuries (Wechsler, Kasey, and Thum 1969; Dietz and Baker 1974; Davis and Smith 1982; Mierley and Baker 1983; CDC 1984; Pleuckhahn 1984; Smith and Kraus 1988). For example, alcohol abuse underlies more than one-fifth of nonvehicular trauma deaths in urban areas of Papua New Guinea (Sinha, Sengupta, and Purohit 1981; Attah Johnson 1989). Alcohol and other drug abuse is known to be a growing problem which has undoubtedly been widely underestimated in developing countries (Edwards 1979; Wyatt 1980; Weddell and McDougall 1981), and its importance needs to be further characterized by epidemiologic research.

Injurious Events

The severity of injuries and the case-fatality rate from them depend largely on their cause. Specific external causes and groups at risk for injury vary widely among countries by level of industrialization and by occupational and cultural practices. Because of the lack of surveillance systems or population-based studies, there is limited information available about injury frequency, risk groups, mechanism, and outcome. Much of the information that has been developed regarding the epidemiology of injury has been descriptive, based on hospital data rather than more reliable community-based studies.

Unintentional Injuries

Fatal injuries in the developing world most often result from motor vehicle collisions, burns, poisonings, drownings, and falls (Manciaux and Romer 1986; Taket 1986; Smith and Barss 1991). As in the industrial countries (Barancik and others 1983), the leading causes of injury deaths are usually not the same as the most prevalent causes of nonfatal injuries. For example, drowning is a frequent cause of death but an infrequent cause of nonfatal injury due to its high case-fatality ratio. The main causes of nonfatal injuries include laceration by cutting and piercing instruments and interaction with animals, in addition to minor motor vehicle collisions and falls. Each of the most important mechanisms of injury are discussed below; data are included from developing countries regarding risk factors as they may pertain to the selection of intervention strategies.

MOTOR VEHICLE COLLISIONS. Among injuries resulting in death, those due to motor vehicle crashes are emerging as the most important for people between the ages of five and forty-five in many developing countries (Jacobs and Sayer 1983; Lourie and Sinha 1983; Mohan and Bawa 1985; Ezenwa 1986a, 1986b). In some countries, particularly the oil-producing countries in which the number of vehicles and roads are rapidly expanding, motor vehicle collisions rank first among causes of death for all ages (Bayoumi 1981). Mixed traffic, which may include trucks, buses, automobiles, motorcycles, mopeds, rickshaws, bicycles, and pedestrians, all moving at different speeds, clearly

predisposes people to collision and injury. Pedestrians and drivers of two-wheeled vehicles are at especially high risk in developing countries, accounting for more than half of all fatalities (WHO 1987b).

Mortality rates per vehicle in Ethiopia and Nigeria in 1978, for example, were fifty times higher than in the United States or United Kingdom (Jacobs and Sayer 1983). Where the use of motor vehicles is rapidly increasing, mortality related to them is also increasing, as has been observed in Thailand, Papua New Guinea (a fourfold increase from 1969 to 1978) (Wyatt 1980), and Malaysia (a fourfold increase in the five years preceding 1975) (Silva 1978). Similar trends have been noted in Latin America and Africa. As development increases further and safety improves, the mortality per vehicle or per mile traveled typically decreases, although the rate per 100,000 population may continue to increase because of increasing exposure.

BURNS AND FIRES. Burns are most prevalent among women and children, with the great majority occurring in domestic environments (Sowemimo 1983; Bang and Saif 1989; Jamal and others 1989). In Lagos, for example, more than half (56.2 percent) of the burn injuries occurred among children less than fifteen years of age. Mortality ranges from 6.7 percent to 35 percent among patients admitted to hospitals (Datey, Murthy, and Taskar 1981; Sowemimo 1983; Bang and Saif 1989; Jamal and others 1989). Burns caused from 15 to 45 percent of all injury deaths seen in three hospital centers in India (Datey, Murthy, and Taskar 1981), where fatality rates among hospitalized patients range up to 35 percent.

In many countries, burns are most commonly sustained by women who work over open stoves or cookfires (Saleh and others 1986; Gupta and Srivastava 1988) and are a significant cause of death for women of childbearing age. Fatal burns in Kanpur, India, occur primarily among young Hindu housewives, whose unintentional burns are frequently attributed to open cookfires or overturning stoves and their loose, highly inflammable clothing. Approximately half of the women who suffer fatal burns, however, are intentionally burned or forced to commit suicide, most often in association with marital disharmony (Gupta and Srivastava 1988). Untreated epilepsy has also been shown to be a risk factor for burns in several studies (Subianto, Tumada, and Margono 1978; Barss and Wallace 1983).

Cigarette smoking, a frequent cause of house fires and death due to burn injuries in the United States (Mierley and Baker 1983; Technical Study Group 1987), needs to be investigated for its role in developing countries as a risk for burn injury and death (Smith and Barss 1991). The prevalence of cigarette smoking, currently on the increase in the developing world, will likely continue to increase as cigarette manufacturers face contracting markets in many industrial countries.

POISONING. In many developing countries, poisoning has emerged as a significant cause of death (Smith and Barss 1991). Local industry and agricultural practices often determine the

epidemiology and causes of poisoning. Traditional healing practices also account for the patterns of acute poisoning in some countries (Joubert and Mathibe 1989). The majority of cases occur among children (Gand, Mohan, and Ghosh 1977; Banerjee and Bhattacharya 1978) and agricultural workers (Hayes 1980; Jeyaratnam, Senevirante, and Copplestone 1982); however, suicide accounts for many of the deaths among adults.

In Sri Lanka in 1978, for example, the more than 1,000 deaths from pesticide poisoning alone greatly exceeded the 572 deaths from polio, diphtheria, tetanus, and pertussis combined (Jeyaratnam, Senevirante, and Copplestone 1982). The United Nations Children's Fund estimates that up to 2 million pesticide poisonings and 10,000 deaths from such poisonings occur annually (UNICEF 1989); however, recent reports from the Philippines suggest that these figures may represent a substantial underestimate (Loevinsohn 1987). Recent evidence also suggests that subacute poisoning and chronic disability may result from continuous low-level exposure. Eighty to 90 percent of pesticide poisonings are caused by highly toxic preparations which account for only 4 to 5 percent of pesticide use (Xue 1987). That developing countries account for more than half of all acute pesticide poisonings and 80 to 99 percent of all deaths from such poisonings, despite their using only 20 percent of the world's pesticide (WHO 1987a; Xue 1987), also indicates that this is an area for intervention.

Accidental ingestion of kerosene is a prominent cause of poisoning among children (Ramesh, Srikanth, and Parvathy 1987; Joubert and Mathibe 1989), most typically when it has been stored in soft drink bottles or other inappropriate containers. An important cause of death in a number of countries is carbon monoxide poisoning, often from motor vehicle exhaust or heating systems, such as those used in Korea, in which hot combustion gases circulated under floors may leak into homes (Lee and others 1971).

Inappropriate use of medications is emerging as an important cause of toxic ingestions, particularly in urban areas. For example, in a recent report from Pakistan, Bhutta and Tahir (1990) describe nineteen cases of loperamide hydrochloride (Imodium) poisoning, of which at least six deaths were a result of inappropriate marketing and use of this antimotility agent for childhood diarrhea.

DROWNING. Ponds, irrigation ditches, and wells in developing countries represent the danger of drowning for young children. In Brazil, drowning occurs most often among children between ten and fourteen years of age and is second only to motor vehicle collisions as a cause of death among these children (de Mello and Bernardes-Marques 1985). In many countries in Asia, drowning is the primary cause of injury death (Ng, Chao, and How 1978; Meade 1980; Selya 1980; Gu and Chen 1982; Kleevens 1982). Many of the deaths among young adults aged fifteen through twenty-four may represent suicide, drowning being a preferred method in Asian countries (Ng, Chao, and How 1978). Drowning is probably underestimated as a cause of death in many countries because so few cases ever

reach the hospital or are reported to police (Smith and Barss 1991).

FALLS. Injury from falls is most prevalent in occupational settings, among young boys, and, where larger such populations exist, among the elderly. Falls from roofs and trees, especially during the harvesting of fruit, are among the most important causes of fatal and nonfatal injury (Barss, Dakulala, and Doolan 1984). The burden on society of these injuries is substantial, particularly in view of the high incidence of paraplegia resulting from spinal cord injury. In Hong Kong, falls accounted for 32 percent of all trauma patients who were discharged from the hospital, and hospitalized patients alone accounted for a reported rate of 416 cases of fall injuries per 100,000 per year prior to 1979, a figure even greater than that for motor vehicle accidents (Kleevens 1982).

OTHER UNINTENTIONAL INJURIES. Animals, bicycles, and cutting tools are additional important instruments of injury in most developing as well as industrial countries (Smith and Barss 1986, 1991), imposing a considerable burden on the health system. Gordon, Gulati, and Wyon (1962) found that 13 percent of injury deaths in rural India were linked to infectious complications of such minor injuries, suggesting that many deaths could be prevented by simple interventions such as proper wound care and tetanus immunization. Permanent disability resulting from ocular trauma, which is responsible for 2.4 percent of all bilateral blindness in Nepal (Schwab 1990), represents another important preventable loss of productivity.

Manmade disasters, such as the chemical leak in Bhopal and the meltdown at the nuclear plant at Chernobyl, underline the importance of chemical agents and nuclear energy in human injury (Bertazzi 1989). These and the natural disasters, such as droughts, earthquakes, and floods, frequently crystallize local and international response more effectively than the less catastrophic but more common causes of injury death. Yet the more than 5,000 reported disasters in the last two decades have affected more than 2.3 billion lives and resulted in more than 4 million deaths (CRED 1991), most of which are due to injury. These episodic calamities remind us periodically of the greater toll of injury in settings where capacity is limited to predict, prepare for, and respond to such events.

OCCUPATIONAL INJURY. Injuries sustained in the workplace, primarily impact and overexertion injuries, are more frequent and perhaps more severe in the developing world. The death rate for factory workers in India, for example, is 50 percent higher than that in the United States (Mohan 1982). The injury rate among coal miners in Nigeria is seven times that for the same occupational group in Britain (Asogwa 1980). In Brazil during 1970, nearly 18 percent of industrial workers were injured (Pupo Nogueira 1987). More than a quarter of industrial workers in Mexico experience a disabling injury each year (Cuellar 1980). The injury of workers in Sri Lanka occurs at a rate of 1,000 per 1,000 or one for every worker per year and

results in permanent disability in 25 percent of cases (Krishnarajah 1972).

Intentional Injury

Distinction among injuries by motive has little import for case management; however, it has clear implications in the selection of preventive strategies. Suicide, homicide, and genocide (including war) are important causes of injury for which preventive strategies must be identified. Terrorism and torture are threats or acts designed to coerce individuals or groups, often resulting in long-term social and psychological injury. Rape and child abuse also inflict psychological injury which can be considerably more disabling than any associated physical injury. More dramatically than in any other cause of injury, males are most commonly the actors in such interpersonal and intergroup violence. Women and children are frequently the victims (Chelala 1990). Locally important factors predisposing people to intentional injuries, such as poverty, racism, social isolation, and drug and alcohol abuse, should be investigated as risk factors (Rosenberg and others 1987).

Criminal homicide represents a significant proportion of injury deaths in many parts of the world. For example, homicide rates of 8.2 per 100,000 population are observed in Latin America; comparable figures are 6.7 for the Caribbean, 4.7 in North Africa and the Middle East, and 2.3 per 100,000 in Asia. Such intentional interpersonal injury is most prevalent in urban areas throughout the world. In the area surrounding Bangkok, for example, homicides are the leading cause of death due to injury, accounting for 27 percent of injury mortality (WHO 1987a). The mortality rate associated with firearms was less than 1 per 100,000 in the United States in 1980; it was nearly 30 per 100,000 in São Paulo, Brazil, in 1984. In neighboring Colombia, the homicide rate per 100,000 inhabitants rose from about 20 in the early 1970s, before drug trafficking became such an important problem, to more than 50 in 1987 (Losada Lora and Velez Bustillo 1988).

Suicide is also probably more important than is suggested by currently available statistics. In Sri Lanka, for example, suicide is the most common cause of injury death, with organophosphate pesticide poisoning a frequent method of choice (Sri Lanka Psychiatric Association 1982; Berger 1988).

The importance of armed combat as a cause of injury morbidity and mortality cannot be ignored. Since 1980, forty-five countries have been involved in forty wars with more than 4 million soldiers globally. More recent wars are tragically distinguished by the occurrence of the majority of the mortality (80 to 90 percent) among civilians, most of whom were women and children. More than 1 million people have perished in Uganda alone during the last twenty years of political unrest. For every death, three times as many people sustain a nonfatal injury (Werner 1987). The more indirect effect of such strife on health status—diversion of national resources to defense from health care—has been pointed out by Ogba (1989) in Nigeria and Chelala (1990) in Central America.

The Public Health Significance of Injury

Worldwide, injury ranks fifth among the leading causes of death, accounting for 5.2 percent of the total mortality (Manciaux and Romer 1986) and 10 to 30 percent of all hospital admissions (WHO 1988). One review of global survey data has suggested that one child in every five to ten sustains an injury each year (Manciaux 1984). A summary of global age-specific patterns of mortality from injury and poisoning is presented as table 25-3. We developed these estimates and projections using the methodology outlined by Alan D. Lopez in chapter 2 of this collection.

Current Levels and Trends in the Developing World

Injury morbidity in developing countries is more difficult to ascertain, because of the lack of adequate community-based studies of injury (Smith and Barss 1991). Data collection regarding the incidence of milder injury is further hampered by the absence of a consistent case definition for injury or disability. In the United States, it is estimated that 1 in 4 people suffer injuries requiring medical attention each year, and 1 in 3 have a day of restricted activity or required medical attention (Collins 1985). The definition of the severity of injuries as either requiring hospitalization or outpatient medical attention is useful for defining the burden to the health system in industrial countries. Such case definitions, however, will clearly record many fewer cases of similar severity in countries in which medical care is less available.

MORBIDITY AND MORTALITY LEVELS, ABOUT 1985. Nearly 3 million deaths are reported from injury and poisoning annually; two-thirds of these occur in the developing countries (WHO 1989c). In many industrial countries, injuries are now the leading cause of death during the first half of the human life span (Baker, O'Neill, and Karpe 1984), and they are becoming one of the leading causes of death and disability in developing countries (Wintemute and others 1985). Because of the greater toll taken by injuries among the work force and younger age groups, however, their importance to the public health is best recognized when measured as years of potential life lost, a reflection of premature mortality.

Although prospective, population-based studies of injuries in developing countries are rare, Gordon, Gulati, and Wyon (1962) demonstrated a low incidence of disabling (that is, causing disruption of normal activity) injury of 111 per 1,000 people per year in eleven very rural Indian villages in 1959. Gordon, Gulati, and Wyon's definition of "injury" as that resulting in short- or long-term disability will be a less sensitive measure of injury morbidity, although this is probably the best definition where medical care is not universally available. In a community-based survey of children in an urban slum of Rio de Janeiro, Reichenheim and Harpham (1989) documented that 30 percent of the children had been injured within the last fifteen days; 85 percent of them were treated at home.

The rates of nonfatal injury in developing countries are probably as high as or higher than those observed in the industrial world. Data from the United States suggest that for every fatal injury there are 16 hospitalizations and almost 400 injuries serious enough to restrict activity or require medical treatment (Rice and others 1989). It is likely that there are also several hundred nonfatal injuries for every fatal injury in developing countries. Because of the lack of available survey methods for identifying and quantifying disability, the real economic and social effect of these injuries is unknown.

TRENDS IN THE PERIOD 1970 TO 1985. Observation of trends in the epidemiology of injury in developing countries raises the question of the relationship between development and injury. Omran (1971) pointed out that developing countries move through an "epidemiologic transition," from a disease profile dominated by infectious diseases to one characterized by the "postransition" noncommunicable health problems, including injury. This transition is brought about through development-associated evolution in three important determinants of the pattern of disease: (a) changes in demographics due to changes in fertility and mortality rates, (b) changes in the prevalence of infectious disease resulting from improved control and reduced incidence, and (c) changes in risk factors resulting from technological and social change.

Demographic changes (such as the shift in age structure and urbanization) have had an effect on the epidemiology of injury primarily through an increase in the incidence of injuries which are more prevalent among the elderly (such as falls) and in urban environments (such as motor vehicle collisions). Reduction in the prevalence of infectious diseases during the past fifteen years has resulted in a growth in the relative importance of injury because it has typically emerged as the most important cause of death for ages one to forty-four.

In many rapidly industrializing countries of the developing world, the absolute injury mortality rates have also grown rapidly. With development have come technological and social changes which alter the risk of injury. These changes have the potential to affect the incidence of injury either adversely (such as through increased hazards or increased risk-taking behaviors) or beneficially (such as through safer products and behaviors). In most developing countries to date, however, these changes in environment and lifestyle have exacerbated rather than ameliorated the problem of injury.

For example, Selya (1980) describes this trend in Taiwan (China), where from 1960 to 1977 unintentional injuries rose from the seventh to the third leading cause of death, and the absolute injury mortality rate increased from 38.9 to 57.2 per 100,000 population. In Shanghai County, China, injuries have already emerged as the leading cause of death for people between the ages of one and forty-five (Gu and Chen 1982).

The increased motorization of transportation in developing countries is perhaps the best-documented example of the unintended negative consequences of technological change. The explosion in the number of roads and vehicles

Table 25-3. Estimated Global Mortality from Injury and Poisoning (by Region, Age, Sex, and Year)
(per 100,000)

Population	1970		1985		2000		2015	
	Male	Female	Male	Female	Male	Female	Male	Female
<i>World</i>								
Under 1	96	84	95	78	78	62	68	50
1-4	99	85	67	57	47	35	43	30
5-14	31	14	28	13	26	11	23	10
15-44	100	22	92	22	86	20	79	19
45-64	124	32	115	31	111	28	107	27
65 and older	216	153	201	140	202	144	205	151
<i>Industrial countries</i>								
Under 1	78	30	63	24	44	19	38	16
1-4	363	312	112	109	28	26	19	20
5-14	24	3	17	2	13	2	11	1
15-44	63	11	53	11	47	8	39	6
45-64	88	28	74	25	84	21	81	20
65 and older	224	188	191	151	209	167	208	168
<i>Nonmarket countries</i>								
Under 1	81	45	86	45	62	36	58	28
1-4	64	49	52	43	45	22	44	25
5-14	32	11	27	10	23	6	22	4
15-44	105	20	88	18	84	14	74	11
45-64	137	33	116	31	116	29	114	27
65 and older	230	155	217	156	208	157	213	155
<i>Latin America and the Caribbean</i>								
Under 1	68	52	101	67	68	47	61	39
1-4	67	44	87	61	45	32	44	23
5-14	32	13	32	14	23	10	22	8
15-44	119	24	105	25	86	21	80	18
45-64	157	35	147	36	114	30	110	29
65 and older	258	133	263	152	206	144	204	151
<i>Sub-Saharan Africa</i>								
Under 1	141	126	118	103	99	84	83	66
1-4	74	60	71	56	55	41	50	35
5-14	50	22	42	19	35	15	28	13
15-44	133	26	120	25	108	24	97	23
45-64	149	33	138	32	129	32	123	31
65 and older	210	118	204	120	200	121	199	121
<i>Middle East and North Africa</i>								
Under 1	110	105	103	93	88	74	76	59
1-4	54	47	60	52	48	37	43	31
5-14	36	19	30	14	27	13	23	10
15-44	113	30	103	24	96	23	85	21
45-64	135	34	133	32	124	32	114	30
65 and older	197	110	208	130	202	129	195	127
<i>Asia</i>								
Under 1	94	91	91	82	75	63	66	50
1-4	65	59	58	49	46	36	43	31
5-14	29	15	27	13	25	12	23	11
15-44	104	24	96	24	90	23	81	20
45-64	131	32	124	32	117	30	110	29

Source: Lopez, chapter 2, this collection..

in Saudi Arabia has been associated with an increase in both morbidity and mortality (nearly 600 percent) due to motor vehicle crashes (Ergun 1987; Ofosu 1988). In Thailand, where the motor vehicle mortality rate has increased almost 30 percent each year (Punyahotra 1982), injuries have risen from sixth to first among all causes of death since 1947 (Choovoravech 1980). Motor vehicles alone were responsible for more years of potential life lost than tuberculosis and malaria combined.

The social changes which accompany development have also generally led to an increase in the frequency of injury in developing countries. With the rapid introduction and diffusion of new technologies, they are frequently used without concern for their safety. For example, in India the grain mills were mechanized without appropriate protective shields over drive belts, resulting in an increase in the incidence of severe injury (Gupta, Bhasin, and Khanka 1982). The economic benefits of mechanization of industry or transportation are seen as greater than the cost of injury or death that may result from the inappropriate use of these technologies. The large underclasses found in developing countries, who are virtually denied access to the wealth of the dominant group, have little to lose by high-risk behavior. Hopelessness in the face of poverty, racism, social isolation, and drug and alcohol abuse does not encourage the investments necessary to improve safety or health.

Possible Morbidity and Mortality Patterns: 2000 and 2015

Still, development may be accompanied by technological and social changes that raise income and improve the equity of its distribution. Studies have confirmed that safety is considered a normal good, the demand for which rises with income (Peltzman 1975). The development of a complex institutional structure (including legislation, enforcement, insurance and litigation services, and complex capital markets) helps to reduce the incidence of injury by forcing implementation of safety measures. Such social organization also applies disincentives to the creation or maintenance of hazards by forcing those who do so to compensate the victims of resulting injuries. Individuals and industry may thereby be coerced to reduce injury risks to the larger community if there is public support for such social change.

Mechanization associated with development may reduce the incidence of injury if it reduces the interaction between people and machines or replaces more hazardous methods. In Nigeria, for example, mechanization of a coal mine was associated with a 60 percent reduction in mining injuries as well as a reduced severity of those injuries (Asogwa 1988). In São Paulo, Brazil, in 1970, nearly 18 percent of industrial workers suffered a work-related accident; with increasing mechanization the incidence was reduced to 3.8 percent by 1984 (Pupo Nogueira 1987). Improved traffic safety and occupational injury control measures in the United States resulted in reductions in injury mortality on the road and in the workplace after industrialization had initially brought about increases

(Chesnais 1985). Rising then declining injury rates from motor vehicles, such as those seen in São Paulo, Brazil, during the quarter century beginning in the 1960s (Haight 1980), will likely be observed. Similar trends may be expected in other developing countries as the demand for safety increases.

Growing prominence of alcohol and drug abuse often accompanies economic development. So few developing nations have begun to recognize or address this problem that it will likely worsen before abuse control measures are instituted. The relative lack of mechanisms to implement legislation, taxation, or treatment and rehabilitation for the control of alcohol and drug abuse will also probably hamper efforts to control the associated injuries.

The increasing availability of firearms is likely to increase intentional injuries throughout the world. Global expenditure for arms continues to rise, already exceeding \$1 trillion dollars annually. Arms transfers to developing countries exceeded \$52.7 billion from the United States alone in 1987. There will be, however, tremendous resistance to any international action to halt this lucrative trade in an effort to contain intergroup and international violence.

The currently increasing use of pesticides in agriculture will be associated with an increased risk of poisonings unless the higher exposure can be offset by stringent safety controls and replacement of the more hazardous agents with safer alternatives. Successful implementation of other injury control measures would be expected to interrupt the worsening trends in injury incidence on the road, in the workplace, and in the home. In those countries which have begun to address the potential hazards associated with technological and social development, such as in Europe and North America, the absolute rates of injury mortality have already begun to fall (Baker and others 1992).

Economic Costs of Injury

The annual medical and social costs of injury are estimated to exceed \$500 billion worldwide (WHO 1989a). Injuries are responsible for up to one-third of all hospital admissions (WHO 1989a). In addition to costs for emergency services, tremendous costs are incurred in continuing care, rehabilitation, and lost productivity due to both death and disability. It is estimated that the cost of injury treatment in the United States in 1985 was approximately \$317,000 for each fatality, \$34,000 for each hospitalization, and \$500 for each injury not requiring hospitalization (Rice and others 1989). It has been estimated that the cost of injuries from motor vehicle collisions alone amounts to nearly 1 percent of the gross national product of many developing countries. Thailand, however, estimates that the cost of these injuries is more nearly 2 percent of the gross national product, not including the costs of the long-term disabilities (WHO 1987b).

Because of its high toll among the younger age groups, injury is the main cause of years of potential life lost in industrial countries. In the United States, for example, injury accounts for 40.8 percent of YPLL, at an estimated cost of \$158 billion per

year for both fatal and nonfatal injury (Rice and others 1989). The relative economic importance of injury in developing countries such as Egypt is even greater, where it accounts for 78 percent of YPLL and 10 to 30 percent of all hospital admissions (WHO 1988).

Disability, both temporary and permanent, resulting from nonfatal injury is perhaps the most important, yet often overlooked, cost of injury. There are few studies which quantify such disability in developing countries. In the United States, disability from injury results in a loss of normal activity for an estimated 3 days per person per year (Smith and Kraus 1988). In a study in Sri Lanka, Krishnarajah (1972) showed that the disability which resulted from industrial injuries accounted for annual losses of 1.6 million working days. The World Health Organization (WHO 1986) estimates that 13 percent of the world's population is disabled and that at least 15 percent of these disabilities result from injury. These data suggest that of 78 million persons (2 percent of the world's population) disabled because of injury, most live in developing countries, where disabilities frequently become handicaps because of the lack of appropriate rehabilitation services.

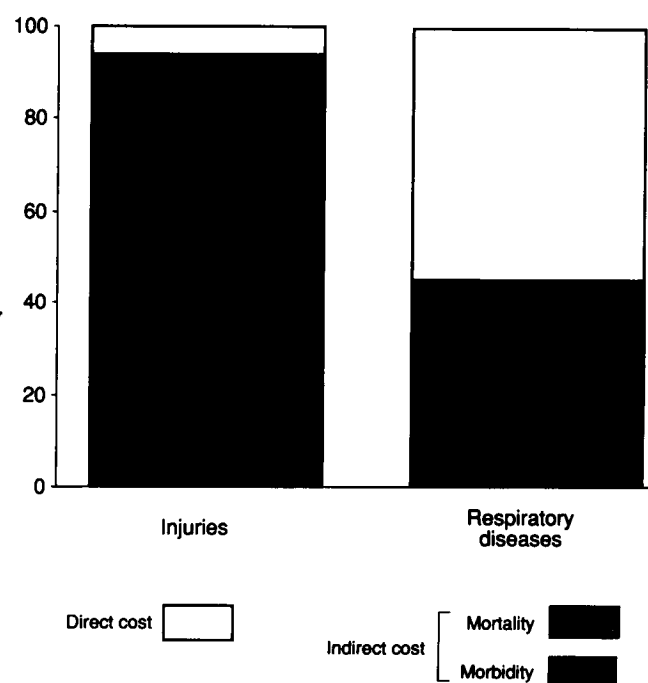
Although little such cost data are available from the developing world, in a study in northeast Brazil, DeCodes, Baker, and Schumann (1988) assessed the direct and indirect costs of various categories of illness. Although injuries accounted for only 11.8 percent of all direct costs of disease or injury, they accounted for 27.5 percent of indirect and 25.5 percent of total costs. Most (68.7 percent) of the total injury costs accrue from disability-related losses in productivity, whereas approximately a quarter (25.3 percent) of the costs are from loss of life. In figure 25-2 we compare these findings by DeCodes, Baker, and Schumann to the analogous figures for respiratory diseases.

The costs of lost productivity and medical care for injury are often exceeded by costs of property damage, insurance, and other nonmedical items. Researchers who conducted a survey of five developing countries (Turkey, Thailand, and three African countries) between 1961 and 1971 found that damage to vehicles and property accounted for 60 to 87 percent of the costs resulting from vehicle crashes (Jacobs and Sayer 1983; Baudouy 1989). In no case did medical costs exceed 9 percent of the cost of crashes. Medical attention and subsequent disability payments account for only one-fifteenth of an estimated \$1.5 billion in annual traffic-accident costs in Brazil (Airton Fischmann, personal communication, 1988).

Lowering the Incidence and Severity of Injury

As emphasized in figure 25-1, the opportunities for prevention of injury lie in alteration of the risk factors (to reduce the probability of injury) and of the injurious events (to reduce the severity of injury). The strategies designed to reduce the consequences of injury are discussed later, in the section on case management.

Figure 25-2. Direct and Indirect Costs of Injuries and Respiratory Diseases



Source: DeCodes, Baker, and Schumann 1988.

Elements of Preventive Strategy

Of the risk factors for injury incidence and severity included in table 25-2, those most amenable to change include alcohol use, unsafe behaviors due to poor safety education, and poor product design. For each of the interventions designed to reduce these risks, we summarize in table 25-4 calculations of expected disability-adjusted life-years (DALYs) gained by the prevention of injuries from motor vehicles, falls, burns, and toxic substances. The derivations of the estimates and calculations in table 25-4 are described in appendix 25A.

Candidate preventive interventions should be assessed for their expected cost and effectiveness prior to implementation. Proposed interventions may then be assigned a priority by a multidisciplinary body of community members and experts in injury control, which must include persons familiar with local sociocultural constraints. For example, Calonge (1987) has identified six factors for consideration in selecting an intervention strategy for injury control: (a) demonstrated efficacy in reducing injuries; (b) demonstrated effectiveness when implemented; (c) public acceptance; (d) ease of implementation considering political, economic, and logistic barriers; (e) level of personal commitment required; and (f) cost-effectiveness. A sample semiquantitative framework for assigning priorities to interventions for reduction of injury from motor vehicle collisions is provided in table 25-5.

The strategies for implementing preventive interventions include: engineering; legislation, regulation, and litigation;

Table 25-4. Effectiveness of Interventions for Injury Control in Developing Countries

Demographic and intervention parameters	Transportation injury	Fall injury	Burn/fire	Poisoning
<i>Demographics</i>				
Incidence (per 100,000)	665	2,000	600	100
Case-fatality ratio (percent)	1.7	0.2	1.0	6.0
Average age at onset	30	30	10	10
Morbidity (life-years lost) per injury	0.22	0.03	0.86	0.01
DALYs lost	3,098	1,278	13,438	180
<i>Preventive interventions</i>				
<i>Alcohol taxation</i>				
Reduction in incidence (percent)	30	26	34	8
DALYs gained	929	332	4,569	14
<i>Product/environmental improvements</i>				
Reduction in incidence (percent)	70	50	70	80
DALYs gained	2,169	639	9,407	144
<i>Behavioral change</i>				
Reduction in incidence (percent)	40	40	50	40
DALYs gained	1,239	511	6,719	72
<i>Case Management interventions</i>				
<i>Acute care improvement</i>				
Reduction in case-fatality ratio (percent)	50	50	60	60
Reduction in disability (percent)	50	50	86	60
DALYs gained	1,549	639	11,557	108
<i>Rehabilitation care</i>				
Reduction in disability (percent)	70	70	70	70
DALYs gained	2,169	909	9,407	126

Source: Authors' data.

taxation and other economic incentives; and education. The effectiveness of an injury control program will depend not only on the effectiveness of the intervention (seat-belt use *does* reduce injuries), but also on the effectiveness of the mechanisms used to promote or implement that intervention (health education in the absence of supportive legislation and enforcement, for example, has not been effective in changing patterns of seat-belt use; see Robertson and others 1974).

ENGINEERING. Perhaps the most effective injury control strategies are those that alter the design of environmental features (such as roads) or equipment to reduce or eliminate the risk of injury. Such passive interventions, which do not rely on changes in volitional behavior, are generally more likely to be effective than those that require the active participation of the individual to reduce injury risk. Air bags, for example, which inflate automatically in a motor vehicle crash will provide passive protection even of occupants who fail to wear seat belts.

Manufacturers seeking to limit costs of improving product safety frequently argue that customers should be given the freedom to choose less expensive products without added safety features. This issue is raised in both industrial and developing countries. The difficulty, however, of ensuring individual "informed consent" to the risks of using unsafe products and the costs to the society that are imposed by injuries must be considered by governments in establishing policy.

LEGISLATION, REGULATION, LITIGATION. Because of the failure of corporations and industry to regulate themselves in matters of product safety, it becomes incumbent upon governments to provide requirements or incentives to protect their citizens. Powerful industry lobbies are often formed to resist such efforts. For example, U.S. legislators concerned with safety have been unable to ban the use of additives in cigarettes that enhance their burning, although such a ban would help to prevent the house fires which claim more than 2,300 lives annually in the United States (Smith and Barss 1986; Technical Study Group 1987). Some legal and regulatory strategies have been more effective in altering injury frequency and severity. Legislation or regulation in the mid-1970s to improve automobile safety (for example, through design standards for brakes, door locks, restraints, fuel systems) is credited with saving 9,000 lives annually (Robertson 1981). Most of these interventions were actually developed by industry itself but were not implemented initially because of short-term cost considerations.

In industrial countries, litigation or the fear of it has led to increasing corporate responsibility for providing safer workplaces and products (Teret and Jacobs 1989). In the United States, for example, some states have strict product liability laws that impose penalties if injuries occur that could have been prevented through use of state-of-the-art safety designs (Robertson 1983). Although litigation may be an important means of injury control in the United States, its applicability in developing countries is likely to be limited for the near future.

Table 25-5. Sample Programs for Control of Injury from Motor Vehicle Collisions

Phase	Intervention	Expected impact	Acceptability	Feasibility/Enforceability	Low cost	Priority
Pre-event	Adopt the 1975 UN guidelines for issue and validity of driving permits, with periodic visual screening of drivers	++	++	++	++	3
	Initiate vehicle registration requirements, with periodic inspection for safety features	++	++	+++	++	3
	Limit dangerous vehicles (such as motorcycles over 250 c.c.) through taxation or import restrictions	+++	+++	++++	++++	2
	Require imported vehicles to have padded dashboards, anti-lacerative windshields	++++	++++	++++	++++	1
Event	Establish and enforce speed limits	++++	++	+++	++	2
	Identify and improve "black spots" or hazards; divide highways	++++	++++	++++	++	1
	Create pedestrian and bicycle-segregated traffic areas	++++	++	++	+++	3
	Modify roadways through towns to ensure slowing of traffic	++++	++	+++	++	3
	Improve roadside lighting	++	++++	+	+	4
	Mandate and enforce use of seatbelts and child restraint systems in passenger vehicles	++++	+++	++	+++	2
	Mandate and enforce use of crash helmets and daytime headlights for motorcycles	++++	+++	+++	+++	2
	Provide basic emergency care training for police, public transport drivers, and others likely to be first at scene	++++	+++	++++	+++	2
Post-event	Train primary health care workers in injury diagnosis and primary management, including use of local materials for collars, splints, and stretchers	++++	++++	++++	+++	1
	Coordinate local communications and transport resources to provide emergency transport to trauma centers	+++	+++	+++	+++	2
	Regionalize and upgrade trauma care in urban centers	+++	++++	+++	+	2
	Improve or develop community-based rehabilitation services, including training and referral resources at regional trauma centers	++++	++++	+++	+++	2

+ Low, ++ moderate, +++ high, ++++ very high.

Source: Authors' data.

TAXATION AND SUBSIDY. Taxes and other economic incentives have been used creatively to reduce injury frequency and severity. Reductions in insurance rates for vehicles equipped with airbags, for example, have been used to promote their selection by consumers and thereby reduce the severity of injury in motor vehicle crashes. Taxes on the use of private vehicles combined with subsidies of safer modes of transportation (such as trains and buses) can help to shift transportation preferences and reduce injury because all forms of mass transportation experience much lower death rates than do private vehicles for the same number of miles traveled (Baker and others 1992).

Taxation has been particularly effective in modulating behaviors such as alcohol use. Alcohol sales and consumption have been shown to be elastic such that price increases through taxation effectively reduce consumption (Cook 1981). A recent study estimated that a tax of approximately 35 percent on the retail price of beer in the United States would eliminate half the alcohol-related fatalities, and a 50 percent tax would eliminate approximately 75 percent of these deaths (Phelps 1988). There is evidence to suggest that consumers in devel-

oping countries may be even more responsive to price changes (Warner 1990), and excise taxes have already been successful in reducing cigarette consumption in Papua New Guinea (Chapman and Richardson 1990).

Because most of the alcohol consumed in developing countries is produced indigenously, it is frequently argued that state monopoly systems should be instrumental in preventing alcohol abuse. Although the feasibility of control over traditional, noncommercial alcohol production and consumption must be considered, the potential profit (as well as public health benefits) of state taxation and control of alcohol should provide incentives for adopting national preventive policies. Successful state control cannot be implemented, however, without public support and stable political conditions. If national alcohol policy is not viewed as a reflection of the society's attitudes, black market trade in alcohol quickly emerges, undermining national control and revenues.

Successes have been achieved in the Gambia, for example, where 90 percent of alcohol is consumed as palm wine (made from the sap of the trees); fees are collected for the license to tap the palm trees and for distribution to the local markets

(Kortteinen 1989). The economic significance of trade in palm wine in rural areas is immense and represents an opportunity for governments to provide disincentives for alcohol abuse through taxation and to finance other costs of alcohol abuse prevention or treatment with the revenue generated.

The availability of highly dangerous products may also be shaped by economic incentives through the use of import duties. Although duties on the import of every potentially dangerous product may raise the cost of doing business and retard economic growth, a more targeted strategy could limit injury frequency and severity without hampering development. For example, commercial interest in the importation of more dangerous technologies might be altered in favor of safer products by imposing a tax on imports which is proportional to the risk of injury. The structure of duties could be adjusted to encourage import, for example, of less toxic pesticides or safer cookstoves. Control or even elimination of the importation of many products (such as handguns or other firearms), could probably be more effective in developing countries than it is in industrial countries because local production is more limited.

EDUCATION. Education is frequently advocated to effect changes in environmental and behavioral factors which alter risk of injury, yet there is little evidence to support the effectiveness of such interventions, even in the industrial world. The most promising results have been achieved with educational interventions which are intended to prompt a single behavior (such as installation of smoke detectors) rather than sustained behavior change (such as seat-belt use or reduction in alcohol use; see Robertson and others 1974; Miller and others 1982). Training workers in safe work habits has been shown to reduce the risk of injury, although the behavior changes were not sustained for long periods after that training (Margolis and Kroes 1975). It may be pointed out that the generally lower level of knowledge about safety in many developing countries may leave more room for gains to be made through education. Educational interventions have been most effective, however, when used in support of legislative, taxation, or engineering interventions, to increase their acceptability (National Committee for Injury Prevention and Control 1989).

Good Practice and Actual Practice: Are There Gaps?

Injury has not been recognized as a preventable public health problem worthy of allocation of resources proportionate to its importance. It is demonstrated in figure 25-3, for example, that research funding for cancer in the United States is more than twenty-one times that for injury when compared on the basis of preretirement years of life lost (NRC/IOM 1985). Moreover, the research information vacuum created by the historical lack of resources has been used to explain continuing neglect of the injury problem. In recent years, however, in both industrial and developing countries, injury control has been given higher priority than it had previously.

An additional obstacle to the development of comprehensive preventive programs has been the inherent need for interdisciplinary and multisectoral action for injury control. Although the health sector might best take the lead, health ministries rarely have had the inclination or power to coordinate the multiple disparate groups necessary to plan and implement the necessary environmental, policy, and behavioral changes. Agencies responsible for public health; curative and rehabilitative health care; legislative affairs; public policy; criminal justice; sociologic, psychiatric, and anthropologic investigation; occupational hazards (including agricultural pesticides); regulation of alcohol and drug use; education; and transportation safety must all be coordinated to ensure a comprehensive preventive strategy.

Despite these obstacles, many developing countries have made significant progress in strengthening injury prevention. Eleven of thirty-two developing countries in a recent survey (WHO 1989c) have established a coordinating body for injury prevention or traffic safety. Many have also established strategies for planning and financing research and injury control activities. The World Health Organization's Injury Prevention Programme provides assistance to member countries in the planning and implementation of national injury control programs.

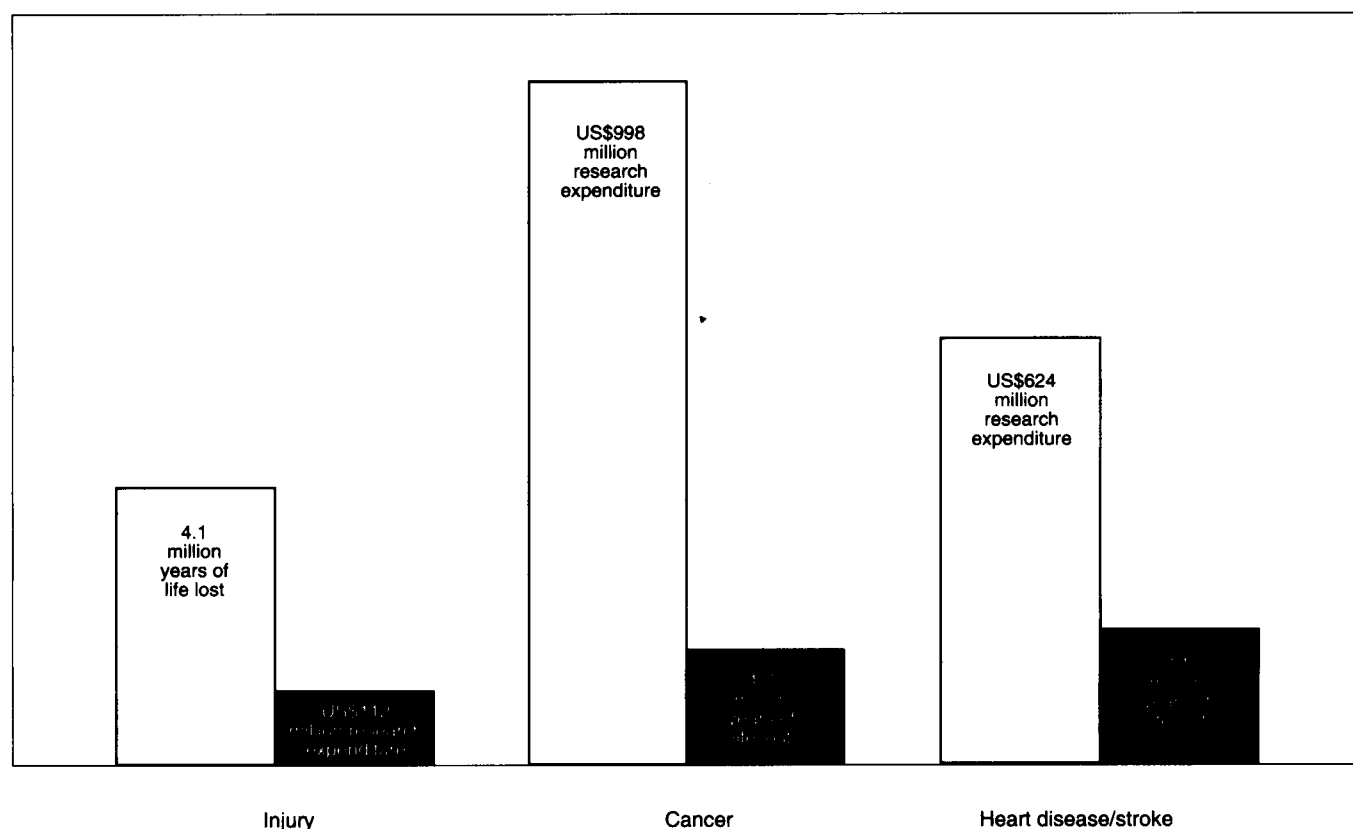
For example, countries such as Nigeria have begun to recognize the need for national policy to address the growing problem of alcohol-related injury. Odejide, Ohaeri, and Ikuesan (1989, p. 235) have called for policy reform, including "legislation on age limit for purchasing or drinking alcohol in public places; legislation on drunk driving behavior; control of alcohol advertising and period of sale; provision of breathalyzer equipment in hospitals; provisional law enforcement agents; and massive education on the issue."

Although many preventive technologies have been developed in industrial countries, there is no reason to believe that most would not be applicable in developing countries. Many proven preventive measures are not costly, yet they have not been adequately exploited to reduce injury frequency and severity in the developing world.

For example, the 27 percent reduction in passenger car deaths observed in the United States from 1965 to 1985 (despite a near doubling of mileage exposure) would probably be reproducible in many developing countries (Ezenwa 1986b). This success was attributed to improved roads (National Safety Council 1986) and progress in making passenger vehicles more crash-worthy (Campbell 1987). The decline in motor vehicle mortality observed in São Paulo, Brazil, since 1980 has also been ascribed to multiple preventive interventions, including better control of driving speeds, greater police surveillance, improved traffic engineering, and placement of more footbridges over principal thoroughfares (de Mello and Bernardes-Marques 1985).

Seat belts are infrequently used in most developing countries, although they might be expected to reduce the risk of fatality by 43 percent (Evans 1986) and serious injury by 40 to 70 percent in motor vehicle crashes (SAE 1984) on the basis of

Figure 25-3. Preretirement Years of Life Lost Annually and Federal Research Expenditures for Major Causes of Death, United States



Source: NRC/OM 1985.

the experience in the United States. In Singapore, a seat-belt law accompanied by education and law enforcement efforts have already successfully reduced motor vehicle injuries (Chao, Khoo, and Poon 1984).

Other legislative interventions which have been effective in industrial countries and would be of benefit in developing countries include laws requiring motorcyclists to use helmets and to have their headlights on at all times (Muller 1982; Zador 1983). The repeal of a mandatory helmet law in Texas was followed by a 73 percent increase in fatalities and 20 percent increase in injuries associated with motorcycle accidents. The high incidence of crash injury and mortality among motorcycle riders in developing countries also suggests that such laws concerning helmet and headlight use may be effective. Even in India, where cultural traditions restrict helmet use, studies showed that turbans offer partial protection from head injury (Sood 1988).

Evidence suggests that reducing the flammability of clothing (such as by using a borax rinse) and its looseness may be expected to reduce morbidity and mortality from burn injury (Durrani 1974; Durrani and Raza 1975; McLoughlin and others 1977). Improved design and safer use of stoves and lamps would also be expected to reduce burn injury (Auchincloss and Grave 1976; Lee 1982; Wintemute and others 1985). Epilepsy

is frequently associated with burns and drownings, suggesting that better treatment could reduce the incidence of injuries in persons with poorly controlled seizure disorders (Buchanan 1972; Pearn, Bart, and Yamaoka 1978; Subianto, Tumada, and Margono 1978; Sonnen 1980; Barss and Wallace 1983).

There is an urgent need to apply already existing preventive strategies, such as reducing availability of dangerous drugs, use of childproof caps, and proper storage of toxic substances, to reduce poisonings in developing countries (Oliver and Hetzel 1972; Baker, O'Neill, and Karpe 1984). Information from developing countries suggests that regulation and education to reduce inappropriate use of medications and other poisonings by better packaging and labeling, addition of emetics or stenchants, and restriction of the availability of highly toxic preparations would also be expected to reduce morbidity and mortality (Mowbrey 1986; Choudry and others 1987).

In Zimbabwe, for example, 34 percent of agricultural workers working with dangerous pesticides reported they had received no safety instruction, and 38 percent believed that pesticide containers could be reused for other purposes, such as storing food or drinking water (Bwititi and others 1987). A program to reduce pesticide poisonings in China through regulation, education, and other preventive measures resulted in a reduction in incidence of more than 98 percent, despite a

nearly thirteenfold increase in the use of pesticides during the same period (Shih and others 1985).

Studies from industrial countries show that legislation mandating adequate fencing, together with self-closing, self-locking gates, around swimming and other pools of water can prevent most toddler drowning deaths (Milliner, Pearn, and Guard 1980). Improved supervision and enclosure of small ponds, wells, and drainage canals in residential areas in developing countries would also be expected to reduce drowning deaths among children (Gordon, Gulati, and Wyon 1962; Nixon, Pearn, and Dugdale 1979; Thapa 1984).

Other examples of proven technologies which are under-used include safety guards to prevent hair or clothes from being caught in drive belts (Gupta, Bhasin, and Khanka 1982). The important problem of injury due to falls must be addressed using locally appropriate strategies. For example, use of the new, shorter hybrid varieties of tropical trees such as mango and oil or coconut palms would undoubtedly prevent many serious injuries in areas where these products are prominent. Falls from rooftops, windows, or into wells can clearly be prevented by appropriate design modifications or barriers.

Regulations for safe workplace conditions and regular inspections can clearly reduce injuries. In Brazil, a 79 percent reduction in the proportion of industrial workers suffering accidents between 1970 and 1984 has been ascribed to legislation regarding the protection of workers (Pupo Nogueira 1987).

For criminal assault, homicide, and suicide, limiting access to the means, such as firearms and medications, is likely to be the most effective means of prevention. The evidence from the United States and Canada suggests that the reduction of the availability of weapons which inflict fatal injury would be effective in reducing the incidence of homicide and suicide (Sloan and others 1988). Elimination of carbon monoxide from the coal gas in Birmingham, England, resulted in a 50 percent reduction in suicide deaths (Hassall and Trethowan 1972). Selection of effective strategies to prevent homicide, suicide, and genocide (including war) must also clearly take cultural factors into account.

The prevention of arms sales to countries at war is one strategy that would be effective if international cooperation could be achieved. Yet the barriers to rational public health policy for the prevention of war are great. Werner (1989) poses the key question: Has the huge arms industry been created in the service of national security, or has the national security paranoia been created in the service of the arms industry? Industry's pressures upon governments and governments' pressures upon international agencies may explain the otherwise incredible neglect of this important public health problem.

Case Management

Although preventive strategies to control injury primarily seek to alter the external causes of injury, case management interventions act to limit or reverse the pathological outcome of injuries. It is the extent or character of the pathological out-

come which generally guides case management decisions. Decisions in the transport or care of the injured must also consider the mechanism or external cause of injury, however, because this clinical history may be the sole clue to serious injury which is occult or late in manifestation.

Elements of the Case Management Strategy

Deaths due to trauma in the industrial world have been described by Trunkey (1983) as occurring in three periods after the injury. "Immediate" death, occurring within an hour of the injury, is generally the result of massive injury. "Early" deaths are defined as those occurring one to three hours after the injury, are generally from internal or other bleeding, and are regarded as being preventable through early, good quality, medical and surgical care. The "late" deaths occur days to weeks after the injury and are generally due to infectious complications or multiple organ failure. Trunkey estimates that more than half of the trauma deaths in the United States are immediate, and approximately 30 percent are early. In the developing world, however, it appears that many more deaths occur in the early and late periods, suggesting that considerable death and disability might be prevented through improvement in the quality of care and transport.

Five major factors are linked to the outcome of care for the injured: the severity of the injury, the age of the injured individual, the preexisting health status of the injured individual, the time elapsed from injury to definitive care, and the quality of care. Therefore, once an injury is sustained, the strategies available to reduce morbidity and mortality through improved case management are improvement in the quality of care, improvement in the emergency transport system, or both.

IMPROVED QUALITY OF CARE. The overall excess case-fatality ratio of injuries sustained in the developing world also suggests room for intervention through improved case management (WHO 1988). There is evidence that modern treatment techniques can reduce mortality rates of burn victims (Demling 1985) and that early and effective rehabilitation of such victims can reduce disability (Sinha 1984). Many needless deaths are caused by preventable complications of minor injuries, such as bleeding and infection. Gordon, Gulati, and Wyon (1962) found, for example, that three of twenty-three (13 percent) deaths from injury were from infections following the injury. There is little information on the cost-effectiveness of improving the quality of care. Because these interventions would depend largely on training existing health professionals, however, the expense would likely be minimal.

Even at the community level, appropriate first aid may reduce the consequences of injury. Although there are few prospective studies of the effectiveness of such basic care, not many people would doubt the beneficial effect of controlling hemorrhage, cleansing wounds, or stabilizing fractures. One study in India demonstrated the effectiveness of cooling burns with cold water (Mohan and Varghese 1990). Yet in some

developing countries few community members are familiar with such first-aid principles.

At the primary health care level, workers may provide the care above in addition to managing minor trauma, including simple fractures and minor open wounds and burns. Appropriate immediate stabilization of suspected fractures prior to transport of the injured person, especially in neck injuries, often prevents subsequent paralysis or other disability. Simple removal of toxins and prompt use of emetics at this level may significantly limit the extent of injury due to poisoning. Routine rehabilitation care, such as that after bone fracture, amputation, or burns, is also best conducted at the primary health care level to optimize the function of injured persons within their own community.

More sophisticated care is required at the secondary and tertiary levels for appropriate surgical treatment, such as for thoracoabdominal trauma, and for inpatient care of injury or poisoning. Data from Trinidad and Tobago (Ali and Naraynsingh 1987) suggest that once the injury victim arrives at the hospital, the twofold higher death-to-injury ratio observed there than in North American hospitals might be reduced by improved in-hospital care. In another study, in Natal, Bullock and others (1988) estimated that one-third of deaths due to head injury could have been prevented with adequate medical treatment at referral sites. Adala (1983) found that, in developing countries, treatment of eye injuries in tertiary care centers is often delayed, resulting in extensive infection and loss of sight.

Rehabilitation, although, ideally, community-based, also requires the backup and referral services of secondary and tertiary care centers for specialized problems (Smith and Barss 1991). To limit disability due to injury effectively, rehabilitation requires long-term, multidisciplinary, and comprehensive service delivery. The goal of rehabilitation is the optimal return of function—physical, psychological, social, and vocational—to the injured individual. Rehabilitation is accomplished both through changes in the functional capacity of the disabled person (for example, development of compensatory muscle strength or the use of prosthetics) and through changes in the physical and social environment. Simple rehabilitative practices, such as range-of-motion exercises to reduce contractures after burns, may have tremendous effect in improving function. Strategies which have been outlined for community-based rehabilitation of the disabled with the limited resources available in developing countries (Miles 1985; Werner 1987) can considerably reduce the economic and sociopsychological costs of injury-related disabilities.

In an evaluation of a rehabilitation program for patients with spinal cord injuries in Taiwan, Wong, Chen, and Lien (1981) suggested that significant reduction of disability could be achieved with rehabilitation interventions. After rehabilitation 75 percent of the patients were able to walk unassisted, and 68 percent were able to resume activities of daily living. Of the rehabilitated group, 17.6 percent were able to resume working at their previous occupations, whereas only 5.2 percent of those who received routine treatment were able to do

so, a difference of 70 percent. These observations are supported by the estimates of those concerned with rehabilitation in developing countries that one-half to three-quarters of those rehabilitated can subsequently return to income-generating activities (David Werner, personal communication, 1990).

IMPROVED TRIAGE AND TRANSPORT SYSTEMS. A significant challenge of emergency care of the injured is the process of "triage," which ensures that injury is managed with the appropriate priority and at the appropriate level in the health care system. In multiple injury and disaster settings, it is of paramount importance that case management activities be prioritized and tasks allocated to optimize use of health care resources. Each community must take responsibility for disaster preparedness by ensuring that local resources (for communications, transport, and health care) are assessed, priorities established, and tasks assigned in advance or as promptly as possible.

The model from industrial countries for the case management of injuries includes an elaborate system of emergency medical services (EMS), including communications, transport, and prehospital and hospital care. Although this strategy of case management of the injured is of interest to many developing countries, the cost of such a system is often prohibitive. Even in the United States, EMS systems are generally available only in large urban areas (West, Williams, and Trunkey 1988). The benefits of improved communications and transport systems, however, would be observed in improved case management of other medical and surgical problems, most notably obstetrical emergencies. Among patients transported by EMS systems in the United States, for example, only about one in six has sustained an injury (Meador, Cook, and Larkin 1989).

At least four essential elements should be included in EMS systems: (a) detection and assessment of emergencies; (b) notification and coordination of transport and definitive care services; (c) organization, training, and performance evaluation of key participants in the EMS system; and (d) stabilization and provision of definitive emergency care. If these four elements are developed, integrated, and strengthened appropriately, the EMS system will also be capable of coordinating the medical response to natural or other disasters.

Ali and Naraynsingh (1987), in their study of Trinidad and Tobago, document that excess numbers of injury victims who are alive after the injury event are dying before they reach the hospital, suggesting that mortality could be reduced by basic improvements to transport and prehospital care. Bhatnagar and Smith (1989) point out the increased fatalities associated with lack of transport among soldiers injured in the Afghan war. Compared with their counterparts in wars in which there was prompt access to good medical care, few patients with thoracoabdominal injuries survived long enough to make it to the only hospitals available, which were on the Pakistan border.

Although studies before and after development of improved prehospital care and transport have shown large differences in survival rates (West, Williams, and Trunkey 1988), such sys-

tems should be developed only where good quality definitive care is reliably available. Where such secondary and tertiary care is adequately developed, simple emergency communications and transport systems may effectively reduce injury morbidity and mortality. In their study of one such system in Papua New Guinea, based on radio linkages and intermittent charter use of local aircraft, Barss and Blackford (1983) documented an annual cost per capita of \$0.20 for all medical, surgical, and obstetric conditions, with a cost per life saved of \$450.00.

A telephone-based EMS for prehospital care and transport has been established in five cities and surrounding areas on the three most populated islands in Indonesia (Puspongoro 1989). This system has been successful in providing prompt triage, treatment, and transport during several disasters as well as more than 5,000 routine ambulance responses in Jakarta alone. Similar systems in the Dominican Republic (Eaton and Perez Mera 1989), Egypt (Sarn 1989), and Nigeria (Owosina 1989) have been planned or implemented with creative methods of community participation, financing, and use of currently available resources.

The estimated effectiveness of simple improvements in the acute care and rehabilitation of the injured for four common sources of injury is presented in table 25-4. Effectiveness estimates are stated as DALYs gained as a result of appropriate acute care and rehabilitation. The derivations of the estimates and calculations in the table are described in appendix 25A.

Good Practice and Actual Practice: Are There Gaps?

Efforts to design strategies to reduce injury morbidity and mortality through improved case management are hampered by the lack of data on the effectiveness of such interventions in the developing world. In the absence of such information, many countries' first efforts are focused on emulating the elaborate EMS systems for emergency prehospital care and transport which are such a dramatic element of case management strategies in industrial countries. Many moderately industrial countries might profit from improved triage, regionalization of medical services, communications, and transport systems; however, there is no benefit to saving minutes or even hours of transport time if referral centers are not adequately staffed and equipped to provide definitive trauma care.

Another important obstacle to the development of appropriate primary care for the injured has been the emphasis in developing countries on vertical programs addressing the traditional infectious disease causes of mortality. Few programs emphasizing such a selective strategy incorporate the basic principles of management of minor injuries into the curriculum for training community health workers. Although the additional cost of training workers in basic first-aid practice would be minimal, this opportunity to reduce injury mortality has generally been neglected. Incorporation of first aid into the curriculum in primary schools in developing countries, for example, is an inexpensive intervention which would be effective in reducing the consequences of injury.

Training of currently available personnel at secondary and tertiary care centers in basic trauma care also represents an inexpensive intervention to reduce morbidity and mortality which would probably be effective. For example, existing communications and transport resources (such as police, fire, or military systems) might be used to improve triage and prehospital care, avoiding duplication and limiting costs. In industrial countries, however, creation of separate EMS systems and development of regional trauma centers may represent the most cost-effective next step to reduce injury mortality and disability.

Priorities for Injury Control

Enough is already known to establish the importance of injury as a public health problem in developing countries. Proven interventions exist to begin to address key injury problems. Although more work is needed to define locally specific injury problems further, the need for more information to refine strategies continuously should be addressed in the design of injury control programs but should not delay prompt action.

The First World Conference on Accident and Injury Prevention was held in "response to the urgent need for promoting accident and injury prevention and to mitigate their consequences on the health of people" (WHO 1989a). Policymakers from fifty countries developed a "Manifesto for Safe Communities," elaborating recommendations for action to (a) formulate public policy for safety, (b) create supportive environments, (c) strengthen community action, and (d) broaden public services. They emphasized the need to encourage politicians and decisionmakers to recognize the importance of injury and to identify injury prevention as a priority goal.

Recognizing and addressing the importance of injury will require integrated efforts at the international, national, and community levels. The tasks of highest priority at each of these levels are outlined below.

Priorities for Action by International and Donor Agencies

The focus of the "Manifesto" on the need for injury control action at the national and community levels in developing countries is appropriate. The governments of some of the more economically powerful nations, however, currently defend the profits of their national and multinational industries at the expense of the health and safety of the people of developing countries. Because injurious products, including alcohol, tobacco, pesticides, pharmaceuticals, and arms, are often pressed upon developing countries, little progress can be made in injury control until such marketing tactics have been proscribed.

Yet these industries, which together yield \$619 billion per year (Werner 1989), will not easily be encouraged to be more responsible in their exploitation of the markets of developing countries. They have already successfully blocked legislation designed to restrict or control the export or import of such

hazardous products (Hill 1988; Werner 1989). The first priority for injury control, therefore, is immediate legislative reform in the industrial nations and prompt policy reform both in the industrial countries and in international agencies.

Donor agencies concerned with bilateral development assistance should take responsibility for educating lawmakers and politicians in their own countries to encourage such policy reform. As a first step to restriction of "dumping" of hazardous products, donor agency regulations must ensure that products imported with donor assistance should be made to the same or similar safety standards as those in the donor country and country of origin.

International and donor agencies should assist governments in recognizing that the minimal short-term cost savings in buying such hazardous products is likely outweighed by the social and medical costs of the resulting injuries. The cost savings resulting from the prevention of injury are societal, whereas the costs of specific interventions are often borne by individuals or special interest groups. In order to protect their profit margins, industry can be expected to provide organized resistance to injury prevention. International and donor agencies should support injury control efforts, recognizing that long-term national economic growth will be hampered if safety is sacrificed to spare the short-term profits of these special interest groups.

Donors should complete an assessment of the injury effects prior to funding nonhealth sectors to ensure that hazards, such as those created by the construction of roads or the development of industry or trade, are recognized and minimized. Funding should also be made contingent upon compliance with international standards for worker, roadway, and product safety. Countries may be encouraged to address the public health importance of injury responsibly by earmarking a percentage of the funding for each project to be allocated to injury prevention activities. Donor agencies should also allocate development assistance resources for core funding to support the development of injury control programs and research.

International agencies, such as WHO, should continue to provide information and guidance regarding policy and research priorities of international significance. Other United Nations agencies, including the United Nations Environment Programme and the United Nations Disaster Relief Office, represent global resources which assist nations in achieving disaster preparedness or provide assistance to them during a disastrous event.

International organizations concerned with health, human rights, and security must take courageous action, sometimes against the will of powerful member states, to halt intergovernmental and intergroup violence. Some responsibility also rests with these agencies to coerce the governments of industrial nations to halt the dumping of their unsafe products in developing countries. Many major donor countries, however, which often control the international agencies, will resist such pressure because of the huge financial profits to be made in the sale of hazardous products such as arms.

Priorities for National Action in Developing Countries

Enough is presently known about the importance of injury in developing countries to justify action on a national level in every country. The "Manifesto for Safe Communities" (WHO 1989a, p. 8) states, "As part of its national health plan, each government should formulate a national policy and plan of action to create and sustain safe communities."

Formulation of a national policy and plan of action would best be preceded by a review of the available national data regarding locally important injury problems (Smith and Barss 1991). The first step would be to conduct an assessment of the injury situation, using existing data sources to characterize injury epidemiology, cost and effectiveness of interventions, and needs for additional information. Frequently the data that are already available have not been analyzed or used to develop strategies of injury control. Information available from police or hospital records, for example, should be exploited before additional data needs are identified and new information systems developed.

A national injury control program must establish a mechanism for intersectoral and multidisciplinary collaboration for policy planning and coordination of program implementation. A national injury control program cannot, in view of the need for multisectoral action, be designed as a vertical program to be fully contained within a ministry of health. Central coordination might best be achieved, therefore, through establishment of a task force or coordinating committee which reports directly to senior-level government officials (WHO 1987a). Such an administrative arrangement would also reflect the necessary national political commitment to ensure the cooperation of sectors responsible for education, transportation, industry and trade, housing, legislation, and enforcement.

The central coordinating body should then act to provide the necessary political and technical support for the injury control activities at intermediate (for example, regional or district) and community levels. It is at these levels that specific hazards will most often be recognized and dealt with to prevent injury. The political and technical support will include strengthening education, communication, research, and training for injury control. In establishing priorities and providing support, governments must be mindful of their special responsibility for addressing injury problems among politically and socially disadvantaged groups, such as children, women, and minorities.

Ongoing monitoring or periodic evaluation should be conducted to document the economic effect of injury problems and the cost and effectiveness of interventions. These information systems, once established, will be instrumental in refining strategies for implementation of any successful injury control program. Pilot projects may be established and evaluated prior to the widespread implementation of unproven interventions for injury control.

Governments of developing countries should supervise trading partners and collaborate with donors to ascertain that their countries are not dumping grounds for hazardous products

which have been banned or become less marketable in their country of origin (Navarro 1984). Import policies and duties and national taxes or subsidies should be designed to increase product and environmental safety. Other national legislation should also be reviewed to ensure that it addresses the environmental and behavioral hazards associated with locally important injury problems.

Although no single list of interventions can be appropriate to every developing country, several injury control measures may be identified which address problems common to most countries. The following low-cost interventions are likely to have the greatest cost-effectiveness in most countries and should be considered as first priority actions:

- Import policy and product and environmental improvements to address burn, fall, and poisoning injuries
- Legislation, regulation, and enforcement to improve occupational and transportation safety
- Alcohol abuse control, especially through taxation
- The strengthening of education for first aid and acute care of the injured at the community and primary health care levels
- Maintenance of trained personnel, basic treatment facilities, and essential drugs for secondary-level management and prevention of complications due to injury
- Coordination of existing transport and communications resources to speed access to emergency care at secondary- and tertiary-level health centers
- The strengthening of rehabilitation services at the community level and referral resources at secondary and tertiary levels

Priorities for Action at the Community Level

The impetus for injury control programs comes most appropriately and effectively from the community level. As development permits individuals and communities to take control of the economic and political forces which affect their lives, industry and governments can be pressed to address the public health problem of injury. Grassroots advocacy groups have accomplished much where governments have failed in the industrial world—for example, to change environmental factors (such as product design for safety) and behavioral risk factors (such as alcohol use).

Unfortunately, however, such spontaneous community organization to demand social change is less likely to occur in the politically disadvantaged communities in many developing countries. Communities are unlikely to demand increased personal security when more basic needs are unmet. A larger share of the responsibility for ensuring adequate protection of its citizens will therefore fall to governments until injuries are seen as unacceptable by an organized community.

Meanwhile, however, communities should begin to work with their governments to increase public knowledge of injury problems and demand for safer communities. Organized com-

Table 25-6. Initial Injury Research Priorities

Action	Examples
Develop and test injury surveillance and survey techniques	Identification and quantification of disability; sensitivity and specificity of case definitions
Elucidate local role of specific factors as risk for injury	Alcohol and drugs
Investigate cost, effectiveness, and impact of specific interventions for injury control	Preventive measures (especially those known to be effective in industrial countries); case management at primary health care level; EMS systems; regionalization of care (including trauma and poison control centers); rehabilitation technologies and programs

Source: Authors' data.

munities are best able to recognize local hazards and pressure local and national governments to improve the prevention and treatment of injury. Effective communications to communities regarding injury problems, through both the press and the government, will help ensure community support for injury control efforts.

Collaboration with the private sector may be an important contribution to the success of national injury control programs. Education and communications efforts might best be targeted for private sector decisionmakers, managers, and educators who are in positions to affect preventive practices. Industries may already have well-developed concerns regarding injury prevention and provide a ready source of support for program design and implementation. Many international nongovernmental organizations have stated an interest in injury prevention (WHO 1986), and their local chapters may also help to organize critical support.

Priorities for Injury Control Research

The continuing need for evidence of the effectiveness of specific interventions to aid in program design must be addressed by incorporating strong evaluation or operational research components into every injury control program. Development of the capacity for conducting such operational research must be a high priority for resource allocation. There are many examples of interventions which have had the opposite effect intended, emphasizing the need to assess the effectiveness of every intervention for injury control.

The World Health Organization (1989c) has identified nine areas of injury research: epidemiological and vital statistical, behavioral and psychological, mechanical and biomechanical, therapeutic, rehabilitative, environmental design standards, economic and legislative policy, toxicological and pharmacological, and health systems research. Several research topics which should be of the highest priority because of their impor-

tance for program design are listed in table 25-6. Initiatives in each of these research areas will be most cost-effective if undertaken as operational research, in conjunction with the design, implementation, and evaluation of national, regional, or community programs.

Appendix 25A. Sources of Data for Effectiveness Calculations

Even for industrial countries, the effectiveness of specific injury control strategies has been poorly documented, except for certain motor vehicle injury prevention efforts (Rice and others 1989). The data from developing countries are even more limited, but estimates of the effectiveness of injury control strategies may be made by using the available information and generalizing from the industrial world if these figures are poor or not available. Although the effectiveness of injury control interventions would likely vary considerably from one country to another, figures have been selected which might best represent global averages. The lack of information on the cost of implementing these injury control interventions in developing countries currently precludes calculation of any cost-effectiveness estimates.

The effectiveness estimations presented in table 25-4 are calculated for four of the most frequent causes of injury mortality and disability in developing countries (Manciaux and Romer 1986; Taket 1986). It must be realized, therefore, that because these injuries represent perhaps only 35 to 40 percent of injury disability and mortality, the opportunity for effect on health is much greater than suggested by these four model intervention programs. Estimates are calculated as disability-adjusted life-years gained.

Estimates of percentage reductions in incidence or disability to be achieved with multiple interventions may exceed 100 percent, because there may be considerable overlap in the effect of specific interventions. For example, the same motor vehicle collision injury of an intoxicated driver might be prevented (or reduced in severity) through prevention of alcohol abuse, improved design of the vehicle, or by changing the driver's behavior to incorporate seat-belt use.

For each injury problem, the expected effectiveness of alcohol taxation in the prevention of injury is calculated by multiplying the expected reduction in alcohol-related injury times the proportion of that injury problem which has been attributed to alcohol (CDC 1990), or the "alcohol attributable fraction" (AAF). On the basis of the work of Phelps (1988) and recent suggestions that price elasticity may be even higher in developing countries than that observed in the United States (Chapman and Richardson 1990; Warner 1990), a 75 percent expected effectiveness in reducing alcohol-related injury through taxation has been assumed.

Because data from developing countries regarding the effectiveness of rehabilitation in reducing disability are so limited, the same estimate is used for all four of the injuries. An analysis of a rehabilitation program for patients with spinal cord inju-

ries in Taiwan (China) is detailed earlier in this chapter as an illustration of data contained in table 25-4.

Transportation Injury

The incidence of motor vehicle injury in the United States is 2,266 per 100,000 people; of those injured, 9.7 percent are hospitalized and 0.86 percent (19.4/100,000) are fatally injured (Rice and others 1989). The incidence of all injuries due to motor vehicle collision in developing countries is likely to be at least 665 per 100,000. This estimate is based on the average reported mortality rates for twenty-one developing countries of 11.3 per 100,000 (PAHO 1986) and the injury-to-fatality ratio, or case-fatality ratio (CFR), of 1.7 percent, double that of industrial nations (Ali and Naraynsingh 1987). The CFR for motor vehicle injury of 1.7 percent is consistent with the observed fatalities of 18 to 21 per 100,000 in Argentina, El Salvador, Costa Rica, and Thailand (although a higher rate [34 per 100,000] is found in Mexico, for example, and a lower rate [6 per 100,000] is found in the Philippines).

The average age of thirty at the time of injury reflects the fact that persons injured in motor vehicle collisions in developing countries are older than their counterparts in the industrial world (PAHO 1986; Ali and Naraynsingh 1987; Salgado and Clombage 1988). For those not fatally injured, the morbidity (in life-years lost) per injury is assumed to be the same as the 0.22 calculated by Rice and others (1989) for these injuries.

The likely effectiveness of alcohol taxation as a preventive measure for motor vehicle injury is based on an AAF of approximately 40 percent, as is observed in both the United States (CDC 1990) and Papua New Guinea (Wyatt 1980; Sinha, Sengupta, and Purohit 1981). With the expected 75 percent effectiveness in reduction of alcohol-related fatalities through taxation and other such economic incentives (Phelps 1988), an estimated reduction of injury incidence of 30 percent is calculated.

Environmental and vehicle improvements might be expected to result in at least a 70 percent reduction in incidence or severity of injury due to motor vehicle collisions. Support for this estimate is provided by the 40 percent reduction in mortality observed in the United States resulting only from vehicular improvements (Robertson 1984). It has also been estimated (Smith and Falk 1987; Rice and others 1989) that 75 percent of motor vehicle fatalities could be prevented through the use of currently available vehicular and environmental safety standards (including vehicle modifications, provision of airbags, and reduction of roadside hazards). Behavior change through education and appropriate enforcement of seat-belt use might reduce injury incidence and severity of these injuries by 40 percent (Evans 1986; Rice and others 1989).

Data from Trinidad and Tobago (Ali and Naraynsingh 1987) and similar observations in the United States indicate that improvement of trauma care for victims of motor vehicle injury would result in an estimated 50 percent reduction

in the CFR. A similar reduction in the disability of those not fatally injured is assumed to be achievable with these interventions.

Falls

The incidence of injury due to falls in the United States is 5,184 per 100,000 people; of those injured, 0.1 percent are fatally injured and 6.4 percent require hospitalization (Rice and others 1989). The incidence of injury from falls in developing countries is probably at least 2,000 per 100,000, in view of the observed death rate of 4 per 100,000 and an assumed injury-to-fatality ratio of 0.2 percent (double that observed in the industrial world, as is the case for other traumatic injuries; see Ali and Naraynsingh 1987). The average age of thirty at the time of injury reflects the higher incidence among the elderly and the occupational nature of many of these injuries. For those not fatally injured, the morbidity (in life-years lost) per injury is assumed to be the same as the 0.03 calculated by Rice and others (1989) for these injuries.

The probable effectiveness of alcohol taxation as a preventive measure for injury due to falls is based on an AAF of 35 percent, as is observed in the United States (CDC 1990), and an expected 75 percent effectiveness in reduction of alcohol-related fatalities from falls (Phelps 1988). These figures suggest that a 26 percent reduction in injury incidence and severity may be achieved with high alcohol taxes.

Environmental improvements might be expected to result in approximately a 50 percent reduction in incidence or severity of injury due to falls. Asogwa (1988) observed, for example, a 60 percent reduction in mining injuries (primarily falls) when environmental improvements were made in the workplace in Nigeria. Education designed to improve safety behavior has been observed to reduce the incidence or severity of fall injuries among children by 40 percent (Kravitz 1973). That these estimates are realistic (or even low) is suggested by the 92 percent reduction in injury from falls among children which was reported in New York City following initiation of a program including both environmental regulation and education (Bergner, Mayer, and Harris 1971; Bergner 1982).

Data on excess deaths among trauma victims in Trinidad and Tobago (Ali and Naraynsingh 1987) indicates that improvement of trauma care for victims of injuries from falls would likely result in a 50 percent reduction in the CFR. Although it is likely to be conservative, a similar estimate can be made of the reduction in the disability of those not fatally injured.

Fires and Burns

The incidence of moderate to severe burn injury is probably at least 600 per 100,000 people in developing countries. In support of this estimate, a similar incidence is implied if 2 to 3 percent of such burn victims require hospitalization in Saudi

Arabia (3.7 percent in United States), because the observed hospitalization rate is 16 per 100,000 (Jamal and others 1989). The incidence of burn injury in the United States, for comparison, is 617 per 100,000 (Rice and others 1989).

The average age of ten at the time of injury reflects the higher incidence among children. For example, Sowemimo (1983) and Haberal and others (1987) reported that well over half of burn victims admitted in Lagos (56.2 percent) and Turkey (69.7 percent) were less than fifteen years of age. In each case, most of these were less than six years of age. Similar age distributions for burn injuries have been observed in India (Gupta and Srivastava 1988).

Data from India (Gupta and Srivastava 1988) and Saudi Arabia (Jamal and others 1989) indicate that the CFR for moderate to severe burn injuries is about 1 percent, although mortality rates for hospitalized patients are generally much higher. For comparison, the case-fatality ratio among burn injuries in the United States is 0.4 percent. For those not fatally burned, the morbidity (in life-years lost) per injury is assumed to be the same as the 0.86 calculated by Rice and others (1989) for these injuries.

The likely effectiveness of alcohol taxation as a preventive measure for injury due to fires and burns is based on an AAF of 45 percent, as is observed in the United States (CDC 1990), and an expected 75 percent effectiveness in reduction in alcohol-related fatalities (Phelps 1988). These figures suggest that a 34 percent reduction in the incidence and severity of these injuries might be achieved at a tax rate of 50 percent.

Product improvements such as safer stoves and less flammable clothing might be expected to result in a substantial reduction in incidence and severity of burn injury. Sixty-three percent of burn deaths in Minuflya, Egypt, are of women and are ascribed to overturned portable stoves (Saleh and others 1986); this epidemiology of burns is typical of that in many developing countries. In addition, more than 30 percent of burns are related to clothing ignition (Durrani 1974; Barss and Wallace 1983). In the United States the introduction of improved flammability standards for children's sleepwear reduced these burn deaths among children by more than 98 percent between 1968 and 1980 (Baker, O'Neill, and Karpe 1984). It is therefore estimated that improved stoves and less flammable fabrics in developing countries would achieve approximately a 70 percent reduction in injury incidence.

Educational interventions might also be used to reduce the frequency of overturned stoves. It has been estimated that 90 percent of burns to children in Central Africa might be prevented with simple barriers around open fires and cookstoves (Auchincloss and Grave 1976). Education designed to improve safety behavior is rarely fully effective in altering the target behaviors, however, so the expected reduction in the incidence or severity of these injuries is estimated to be 50 percent (Barss and Wallace 1983; Schelp 1987).

Improvement of trauma care for burn victims would result in an estimated 60 percent reduction in the CFR, if the CFR is reduced to that observed in industrial nations. The observed

reduction in the proportion of burn victims requiring skin grafts when cold water was immediately applied to a burn suggests that this intervention could reduce the disability of those not fatally injured by an estimated 86 percent (Mathews and Radakrishnan 1987). Improved rehabilitation of burn victims would likely contribute an estimated 70 percent reduction in disability, because simple range-of-motion exercises greatly reduce the formation of disabling contractures after burn injury.

Toxic Injury

The incidence of organophosphate poisoning alone is estimated to be 100 per 100,000 people (Xue 1987) in China's largely agricultural society. In Sri Lanka, however, the incidence is probably much greater, because pesticide poisonings severe enough to hospitalize the victim occur in 90 per 100,000 people. Organophosphates account for 20 to 50 percent of poisoning injury, so it can be estimated that the overall incidence of poisoning in developing countries is approximately 300 per 100,000 people. The incidence of injury from poisoning in the United States, for comparison, is 718 per 100,000 (Rice and others 1989). The higher incidence in the United States might be expected in view of the higher prevalence of toxic substance use and the higher likelihood that mild toxicity would be detected.

The average age of ten years at the time of toxic injury reflects the higher incidence among children (Joubert and Mathibe 1989), although many poisonings occur in the workplace. On the basis of the ninefold excess fatality rate among cases of organophosphate poisoning in China (Xue 1987), we estimate the CFR for poisonings to be approximately nine times the 0.7 percent case-fatality ratio in the United States (Rice and others 1989), or 6 percent. This percentage is consistent with average CFRs observed for other toxic ingestions (Shih and others 1985; Joubert and Mathibe 1989; Bhutta and Tahir 1990). For those not fatally injured, the morbidity (in life-years lost) per injury is assumed to be the same as the 0.01 calculated by Rice and others (1989) for these injuries. Although most poisoning victims who survive will recover without disability, the high disability ratio observed, for example, in Bhopal (where 3 to 5 persons were permanently disabled for each of the estimated 10,000 fatalities) suggests that this is probably a conservative estimate.

Alcohol abuse is associated with poisonings from other toxins, especially in suicides. The likely effectiveness of alcohol taxation as a preventive measure for poisoning is based on an AAF of 10 percent, as is observed in toxic ingestions in Sri Lanka (Hettiarachchi and Kodituwakku 1989), and an expected 75 percent effectiveness in reduction of alcohol-related fatalities (Phelps 1988). These figures suggest that alcohol taxation (at a rate of 50 percent) might be expected to result in an 8 percent reduction in toxic ingestions.

Product improvements (that is, use of less toxic preparations of pesticides, child-proof caps, and so on) might be expected

to result in an 80 percent reduction in the incidence and severity of poisoning. A 95 percent reduction in poisonings was observed, for example, with the elimination of carbon monoxide from coal gas in Birmingham, England. Because organophosphates account for nearly half of poisonings, and 80 to 90 percent of pesticide poisonings are caused by highly toxic preparations which account for only 4 to 5 percent of pesticide use (Xue 1987), one could expect nearly a 50 percent reduction in overall poisoning incidence with use of less toxic organophosphate preparations. Educational interventions and safer use of toxic substances might also be expected to contribute a 40 percent reduction in the incidence of poisoning (Shih and others 1985).

Improvement of emergency care for poisoning victims might be expected to result in an estimated 60 percent reduction in the CFR, if fatality rates are reduced to near those observed in industrial countries. Although the disability rate is small, improved rehabilitation for poisoning victims might result in an estimated 70 percent reduction in the severity or duration of disability.

Notes

The authors gratefully acknowledge the support and comments of Susan Baker, Peter Barss, Lawrence Berger, Carlos F. C. Dora, Philip Graitcer, Dean Jamison, Claude Romer, M. C. Thuriaux, and David Werner.

References

- Adala, H. S. 1983. "Ocular Injuries in Africa." *Social Science and Medicine* 17:1729-53.
- Ali, Jameel, and Vijay Naraynsingh. 1987. "Potential Impact of Advanced Trauma Life Support (ATLS) Program in a Third World Country." *International Surgery* 72(3):179-84.
- Armstrong, K., R. Sfeir, J. Rice, and M. Kerstein. 1988. "Popliteal Vascular Injuries and War: Are Beirut and New Orleans Similar?" *Journal of Trauma* 28(6):836-39.
- Asogwa, S. E. 1980. "A Review of Coal-Mining Accidents in Nigeria over a 10-Year Period." *Journal of Social and Occupational Medicine* 30:(2)69-73.
- . 1988. "The Health Benefits of Mechanization at the Nigerian Coal Corporation." *Accident Analysis and Prevention* 20:103-8.
- Attah Johnson, F. Y. 1989. "Prevention and Management of Problems Related to Alcohol Abuse in Papua New Guinea through Primary Health Care." *Medicine and Law* 8:175-89.
- Auchincloss, J. M., and G. F. Grave. 1976. "The Problem of Burns in Central Africa." *Tropical Doctor* 6:114-17.
- Baker, S. P., B. O'Neill, M. J. Ginsbury, and G. Li. 1992. *The Injury Fact Book*. 2d ed. New York: Oxford University Press.
- Baker, S. P., B. O'Neill, and R. S. Karpe. 1984. *The Injury Fact Book*. Lexington, Mass.: Lexington Books.
- Banerjee, P., and S. Bhattacharya. 1978. "Changing Pattern of Poisoning in Children in a Developing Country." *Tropical Pediatrics and Environmental Child Health* 24:136-39.
- Bang, R. L., and J. K. Saif. 1989. "Mortality from Burns in Kuwait." *Burns* 15:315-21.

- Barancik, J. I., B. F. Chatterjee, Y. C. Greene, E. M. Michenzi, and D. Fife. 1983. "Northeastern Ohio Trauma Study: I. Magnitude of the Problem." *American Journal of Public Health* 73:746-51.
- Barss, P. G., and C. Blackford. 1983. "Medical Emergency Flights in Remote Areas: Experience in Milne Bay Province, Papua New Guinea." *Papua New Guinea Medical Journal* 26:198-202.
- Barss, P. G., P. Dakulala, M. Doolan. 1984. "Falls from Trees and Tree Associated Injuries in Rural Melanesians." *British Medical Journal (Clinical Research)* 289:1717-20.
- Barss, P. G., and K. Wallace. 1983. "Grass Skirt Burns in Papua New Guinea." *Lancet* 1:733-34.
- Baudouy, J. 1989. "Road Accidents: An Emerging Epidemic in Developing Countries." Harvard School of Public Health, Boston, Mass.
- Bayoumi, A. 1981. "The Epidemiology of Fatal Motor Vehicle Accidents in Kuwait." *Accident Analysis and Prevention* 13:339-48.
- Berger, Lawrence R. 1988. "Suicides and Pesticides in Sri Lanka." *American Journal of Public Health* 78:826-28.
- Bergner, L. 1982. "Environmental Factors in Injury Control: Preventing Falls from Heights." In A. Bergman, ed., *Preventing Childhood Injuries. Report of the Twelfth Ross Roundtable on Critical Approaches to Common Pediatric Problems*. Ross Laboratories, Columbus, Oh.
- Bergner, L., S. Mayer, and D. Harris. 1971. "Falls from Heights: A Childhood Epidemic in an Urban Area." *American Journal of Public Health* 61:90-96.
- Bertazzi, P. A. 1989. "Industrial Disasters and Epidemiology: A Review of Recent Experiences." *Scandinavian Journal of Work and Environmental Health* 15:85-100.
- Bhatnager, M. K., and G. S. Smith. 1989. "Trauma in the Afghan Guerilla War: Effect of Lack of Access to Care." *Surgery* 105:699-705.
- Bhutta, Tariq Iqbal, and Khalid Iqbal Tahir. 1990. "Loperamide Poisoning in Children." *Lancet* 335:363.
- Bittah, O., J. A. Owola, and P. Oduor. 1979. "A Study of Alcoholism in a Rural Setting in Kenya." *East African Medical Journal* 56:665-70.
- Buchanan, R. C. 1972. "The Causes and Prevention of Burns in Malawi." *Central African Journal of Medicine* 18:55-56.
- Bullock, M. R., M. D. du Treu, J. R. van Dellen, J. P. Nel, and C. P. McKeown. 1988. "Prevention of Death from Head Injury in Natal." *South African Medical Journal* 73:523-27.
- Bwititi, T., O. Chikuni, R. Loewenson, W. Murambiwa, C. Nhachi, and N. Nyazema. 1987. "Health Hazards in Organophosphate Use among Farm Workers in the Large-Scale Farming Sector." *Central African Journal of Medicine* 33:120-26.
- Calonge, N. 1987. "Objectives for Injury Control Intervention—The Department of Health and Human Services Model." *Public Health Reports* 102: 602-5.
- Campbell, B. J. 1987. "Research Trends in Injury Prevention." *Public Health Reports* 102:592-93.
- CDC (Centers for Disease Control). 1984. "Alcohol and Violent Death: Erie County, New York, 1973-1983." *Morbidity and Mortality Weekly Report* 33:226-27.
- . 1990. "Alcohol-Related Mortality and Years of Potential Life Lost—United States, 1987." *Morbidity and Mortality Weekly Report* 39:173-79.
- Chao, T. C., J. H. Khoo, and W. N. Poon. 1984. "Road Traffic Accident Casualties in Singapore (with Special Reference to Drivers and Front Seat Passengers)." *Annals of the Academy of Medicine of Singapore* 13(1):96-101.
- Chapman, S., and J. Richardson. 1990. "Tobacco Excise and Declining Tobacco Consumption: The Case of Papua New Guinea." *American Journal of Public Health* 1990; 80:537-40.
- Chelala, Cesar A. 1990. "Central America: The Cost of War." *Lancet* 335: 153-54.
- Chesnais, J. C. 1985. "The Prevention of Deaths from Violence." In J. Vallin and A. D. Lopez, eds., *Health Policy, Social Policy, and Mortality Prospects*. Institut National d'Etudes Démographiques (INED) and International Union for the Scientific Study of Population (IUSSP), Ordina Editions.
- Choororavech, P. 1980. "Motor Vehicle Accident in Childhood." *Journal of the Medical Association of Thailand* 63:304-9.
- Choudhry, V. P., A. J. Jalali, G. Haider, and M. A. Qureshi. 1987. "Spectrum of Accidental Poisonings among Children in Afghanistan." *Annals of Tropical Pediatrics* 7:278-81.
- Collins, J. G. 1985. *Persons Injured and Disability Days Due To Injuries, United States, 1980-81*. Vital and Health Statistics Series 10, 149. DHHS Publication (PHS) 85-1577. Public Health Service, National Center for Health Statistics, Washington, D.C.
- Cook, P. 1981. "The Effect of Liquor Taxes on Drinking, Cirrhosis, and Auto Accidents." In M. H. Moore and D. R. Gerstein, eds., *Alcohol and Public Policy: Beyond the Shadow of Prohibition*. Washington, D.C.: National Academy Press.
- CRED (Center for Research on the Epidemiology of Disasters). 1991. *Disasters in the World: Statistical Update from CRED Disasters Events Database*. University of Louvain School of Public Health, Brussels.
- Cuellar, A. 1980. "Occupational Health and Safety in the Smelting and Foundry Industries in Mexico." *American Journal of Industrial Medicine* 1: 261-63.
- Curry, Robert L. 1989. "Beverage Alcohol Spending in Singapore: A Potential Development Constraint?" *International Journal of the Addictions* 24(8): 821-28.
- Datey, S., N. S. Murthy, and A. D. Taskar. 1981. "A Study of Burn Injury Cases from Three Hospitals." *Indian Journal of Public Health* 15(3):117-24.
- Davis, S., and L. S. Smith. 1982. "Alcohol and Drowning in Cape Town: A Preliminary Report." *South African Medical Journal* 62:931-33.
- DeCodes, J., T. D. Baker, and D. Schumann. 1988. "The Hidden Costs of Illness in Developing Countries." *Research in Human Capital Development* 5: 127-45.
- de Mello, M. H. Jorge, and M. Bernardes-Marques. 1985. "Violent Childhood Deaths in Brazil." *Bulletin of the Pan-American Health Organization* 19(3): 288-99.
- Demling, R. H. 1985. "Burns (Medical Progress)." *New England Journal of Medicine* 313:1389-98.
- De Wind, Christina M. 1987. "War Injuries Treated under Primitive Circumstances: Experiences in an Ugandan Mission Hospital." *Annals of the Royal College of Surgeons of England* 69:193-95.
- Dietz, P. E., and S. P. Baker. 1974. "Drowning: Epidemiology and Prevention." *American Journal of Public Health* 64:303-12.
- Durrani, K. M. 1974. *The Epidemiology of Burn Injuries*. Burns Research Project, Civil Hospital, Dow Medical College, Karachi, Pakistan.
- Durrani, K. M., and S. K. Raza. 1975. "Studies on Flammability of Clothing of Burn Victims, Changes Therein, and Their Wearability after a Borax Rinse." *Journal of the Pakistan Medical Association* 25(5):99-102.
- Eaton, D., and A. Perez Mera. 1989. "The Rise and Fall of EMS Innovation: A Cautionary Tale from the Dominican Republic." Paper presented at the International Conference on Emergency Health Care Development, Crystal City, Va.
- Edwards, G. 1979. "Drinking Problems: Putting the Third World on the Map." *Lancet* 2:402-4.
- Ergun, G. 1987. "Condition of Vehicles in Saudi Arabia." *Accident Analysis and Prevention* 19:343-58.
- Evans, L. 1986. "The Effectiveness of Safety Belts in Preventing Fatalities." *Accident Analysis and Prevention* 18:229-41.
- Ezenwa, A. D. 1986a. "Prevention and Control of Road Traffic Accidents in Nigeria." *Journal of the Royal Society of Health* 106(1):25-26.
- . 1986b. "Trends and Characteristics of Road Traffic Accidents in Nigeria." *Journal of the Royal Society of Health* 106(1):27-29.

- Fox, D. K., B. L. Hopkins, and W. K. Anger. 1987. "The Long Term Effects of a Token Economy on Safety Performance in Open-Pit Mining." *Journal of Applied Behavior Analysis* 20(3):215-24.
- Gaind, B. N., M. Mohan, and S. Ghosh. 1977. "Changing Pattern of Poisoning in Children." *Indian Pediatrics* 14(4):295-301.
- Gordon, J. E., P. V. Gulati, and J. Wyon. 1962. "Traumatic Accidents in Rural Tropical Regions: An Epidemiological Field Study in Punjab, India." *American Journal of Medical Science* 243(3):158-78.
- Gu, X. Y., and M. L. Chen. 1982. "Vital Statistics (of Shanghai County)." *American Journal of Public Health* 72(supplement):19-23.
- Gupta, R. C., S. K. Bhasin, and B. S. Khanka. 1982. "Drive-Belt or Patta Injuries." *Injury* 13(6):495-99.
- Gupta, R. K., and A. K. Srivastava. 1988. "Study of Fatal Burn Cases in Kanpur (India)." *Forensic Science International* 37(2):81-89.
- Haberal, M., Z. Oner, U. Bayraktar, and N. Bilgin. 1987. "Epidemiology of Adults' and Children's Burns in a Turkish Burn Center." *Burns Including Thermal Injuries* 13(2):136-40.
- Haddon, W., Jr. 1970. "On the Escape of Tigers: An Ecologic Note." *American Journal of Public Health* 60:2229-34.
- . 1980. "Options for Prevention of Motor Vehicle Injury." *Israel Journal of Medical Science* 16:45-65.
- Haight, F. A. 1980. "Traffic Safety in Developing Countries." *Journal of Safety Research* 12:50-58.
- Hassall, C., and W. H. Trethowan. 1972. "Suicide in Birmingham." *British Medical Journal* 1:717-18.
- Hayes, W. J. 1980. "Factors Limiting Injury from Pesticides." *Journal of Environmental Science and Health* B15(6):1005-21.
- Hettiarachchi, J., and G. C. S. Kodituwakku. 1989. "Self Poisoning in Sri Lanka: Motivational Aspects." *International Journal of Social Psychiatry* 35(2):204-8.
- Hill, R. 1988. "Problems and Policy for Pesticide Exports to Less Developed Countries." *Natural Resources Journal* 28(4):699-720.
- Jacobs, G. B., and I. Sayer. 1983. "Road Accidents in Developing Countries." *Accident Analysis and Prevention* 15:337-53.
- Jamal, Y. S., M. S. M. Ardawi, A. A. Ashy, H. Merdad, and S. A. Shaik. 1989. "Burn Injuries in the Jeddah Area of Saudi Arabia: A Study of 319 Cases." *Burns* 15:295-98.
- Jeyaratam, J., R. S. de Alwis Senevirante, and J. F. Copplestone. 1982. "Survey of Pesticide Poisonings in Sri Lanka." *Bulletin of the World Health Organization* 0(4):615-19.
- Joubert, P. H., and L. Mathibe. 1989. "Acute Poisoning in Developing Countries." *Adverse Drug Reactions and Acute Poisoning Reviews* 8(3):165-78.
- Kleevens, J. W. 1982. "Accidents in Hong Kong." *Public Health, London* 96(5):297-304.
- Kortteinen, Timo 1988. "International Trade and Availability of Alcoholic Beverages in Developing Countries." *British Journal of Addiction* 83:669-76.
- . 1989. "State Monopoly Systems and Alcoholism Prevention in Developing Countries: Report on a Collaborative International Study." *British Journal of Addiction* 84:413-25.
- Kravitz, H. 1973. "Prevention of Falls in Infancy by Counseling Mothers." *Illinois Medical Journal* 144:570-73.
- Krishnarajah, V. 1972. "Industrial Accidents—A Survey." *Ceylon Medical Journal* 18-27.
- Landemann Szarcwald, C., and E. Ayres de Castilho. 1986. "Mortalidade por causas externas no estado de Rio de Janeiro no periodo de 1976 a 1980." *Cadernos de Saude Publica, R.J.* 1:19-41.
- Langley, J. D. 1988. "The Need to Discontinue the Use of the Term 'Accident' when Referring to Unintentional Injury Events." *Accident Analysis and Prevention* 20:1-8.
- Lee, K. N., Y. O. Choi, C. H. Kim, and D. R. Yun. 1971. "An Epidemiological Study on the Incidence of Carbon Monoxide Poisoning in Korea." *Journal of the Korea Preventive Medicine Society* 4:95-106.
- Lee, S. T. 1982. "Two Decades of Specialized Burns Care in Singapore." *Annals of the Academy of Medicine of Singapore* 11(3):358-65.
- Loevinoshn, M. E. 1987. "Insecticide Use and Increased Mortality in Rural Central Luzon, Philipinnes." *Lancet* 1:359-62.
- Losada Lora, R., and E. Velez Bustillo. 1988. "Muertas violentas en Colombia, 1979-1986." Instituto SER de Investigación, Bogotá, Colombia.
- Lourie, J., and S. Sinha. 1983. "Port Moresby Road Traffic Accident Survey." *Papua New Guinea Medical Journal* 26:186-89.
- McLoughlin, E., N. Clarke, K. Stahl, and J. D. Crawford. 1977. "One Pediatric Burn Unit's Experience with Sleepwear-Related Injuries." *Pediatrics* 60:405-9.
- Manciaux, M. 1984. "Accidental Injuries in the Young: From Epidemiology to Prevention." *Effective Health Care* 2(1):21-28.
- Manciaux, M., and C. J. Romer. 1986. "Accidents in Children, Adolescents, and Young Adults: A Major Public Health Problem." *World Health Statistical Quarterly* 39:227-31.
- Margolis, B., and W. Kroes. 1975. *The Human Side of Accident Prevention*. Springfield, Ill.: Charles C. Thomas.
- Mathews, R. N., and T. Radakrishnan. 1987. "First Aid for Burns." *Lancet* 1:1371.
- Meade, M. S. 1980. "Potential Years of Life Lost in Countries of Southeast Asia." *Social Science and Medicine* 14D:277-81.
- Meador, S., R. T. Cook, and G. L. Larkin. 1989. "Advanced Life Support Medical Care Distribution in a Rural/Urban Population." Paper presented at the International Conference on Emergency Health Care Development, Crystal City, Va.
- Mierley, M. C., and S. P. Baker. 1983. "Fatal Housefires in an Urban Population." *JAMA* 249:1466-68.
- Miles, M. 1984. *Where There is No Rehab Plan*. Mental Health Centre, Peshawar, India.
- Miller, R. E., K. S. Reisinger, M. M. Blatter, F. Wucher. 1982. "Pediatric Counseling and Subsequent Use of Smoke Detectors." *American Journal of Public Health* 72:392-93.
- Milliner, N., J. Pearn, and R. Guard. 1980. "Will Fenced Pools Save Lives? A 10-Year Study from Mulgrave Shire, Queensland." *Medical Journal of Australia* 2:510-11.
- Mohan, D. 1982. "Accidental Death and Disability in India—A Case of Criminal Neglect." *Industrial Safety Chronicle* 24-43.
- Mohan, D., and P. S. Bawa. 1985. "An Analysis of Road Traffic Fatalities in Delhi, India." *Accident Analysis and Prevention* 17:33-45.
- Mohan, D., and M. Varghese. 1990. "Fireworks Cast a Shadow on India's Festival of Lights." *World Health Forum* 11:323-26.
- Mowbrey, D. L. 1986. "Pesticide Poisoning in Papua New Guinea and the South Pacific." *Papua New Guinea Medical Journal* 29:131-41.
- Muller, A. 1982. "An Evaluation of the Effectiveness of Motorcycle Headlight Use Laws." *American Journal of Public Health* 72:1136-41.
- National Committee for Injury Prevention and Control. 1989. "Injury Prevention: Meeting the Challenge." *American Journal of Preventive Medicine* 5(supplement):1-303.
- NHTSA (National Highway Traffic Safety Administration). 1988. *Fatal Accident Reporting System, 1987*. U.S. Department of Transportation, Washington, D.C.
- NRC/IOM (National Research Council/Institute of Medicine), Committee on Trauma Research, Commission on Life Sciences. 1985. *Injury in America: A Continuing Public Health Problem*. Washington, D.C.: National Academy Press.
- National Safety Council. 1986. *Accident Facts*. Chicago, Ill.

- Navarro, V. 1984. "Policies on Exportation of Hazardous Substances in Western Developed Countries." *New England Journal of Medicine* 311:546-48.
- Ng, S. C., T. C. Chao, and J. How. 1978. "Deaths by Accidental Drowning in Singapore, 1973-76." *Singapore Medical Journal* 19:14-19.
- Nielsen, M. F. J., C. A. Resnick, and S. W. Acuda. 1989. "Alcoholism among Outpatients of a Rural District General Hospital in Kenya." *British Journal of Addiction* 84:1343-51.
- Nixon, J. W., J. H. Pearn, and A. E. Dugdale. 1979. "Swimming Ability of Children: A Survey of 4000 Queensland Children in a High Drowning Region." *Medical Journal of Australia* 6:271-72.
- Odejide, A. O., J. U. Ohaeri, and B. A. Ikuesan. 1989. "Alcohol Use among Nigerian Youths: The Need for Drug Education and Alcohol Policy." *Drug and Alcohol Dependence* 23:231-35.
- Ofose, J. B., A. M. Abouammoh, and A. Bener. 1988. "A Study of Road Traffic Accidents in Saudi Arabia." *Accident Analysis and Prevention* 20:95-101.
- Ogba, Leo Oko. 1989. "Violence and Health in Nigeria." *Health Policy and Planning* 4(1):82-84.
- Okonkwo, C. A. 1988. "Spinal Cord Injuries in Enugu, Nigeria—Preventable Accidents." *Paraplegia* 26(1):12-18.
- Oliver, R. G., and B. S. Hetzel. 1972. "Rise and Fall of Suicide Rates in Australia: Relationship to Sedative Availability." *Medical Journal of Australia* 2:919-23.
- Omran, A. R. 1971. "The Epidemiologic Transition: A Theory of the Epidemiology of Population Change." *Milbank Memorial Fund Quarterly* 49:509-38.
- Owosina, F. A. O. 1989. "National Policy on Injury Control and Emergency Medical Services." Paper presented at the International Conference on Emergency Health Care Development, Crystal City, Va.
- PAHO (Pan-American Health Organization). 1986. *Health Conditions in the Americas, 1981-1984*. Vol. 1. Scientific Publication 500. Washington, D.C.
- Patel, N. S., and G. P. Bhagwatt. 1977. "Road Traffic Accidents in Lusaka and Blood Alcohol." *Medical Journal of Zambia* 11(2):46-49.
- Pearn, J. H., R. Bart, and R. Yamaoka. 1978. "Drowning Risks to Epileptic Children: A Study from Hawaii." *British Medical Journal* 2:1284-85.
- Peltzman, S. 1975. "The Effects of Automobile Safety Regulation." *Journal of Political Economy* 83(4):677-725.
- Phelps, C. E. 1988. "Death and Taxes: An Opportunity for Substitution." *Journal of Health Economics* 7:1-24.
- Pleuckhahn, V. D. 1984. "Alcohol and Accidental Drowning: A 25-Year Study." *Medical Journal of Australia* 141:22-25.
- Punyahotra, V. 1982. *Epidemiology of Road Traffic Accident in Thailand*. National Safety Council, National Accident Research Center, Bangkok, Thailand.
- Pupo Nogueira, C. 1987. "Prevention of Accidents and Injuries in Brazil." *Ergonomics* 30(2):387-93.
- Pusponegoro, A. D. 1989. "Pre-hospital Emergency Care in Indonesia: Concepts and Problems." Paper presented at the International Conference on Emergency Health Care Development, Crystal City, Va.
- Ramesh, S., S. Srikanth, and V. R. Parvathy. 1987. "Poisoning in Children." *Indian Journal of Pediatrics* 54:769-73.
- Reichanheim, M. E., and T. Harpham. 1989. "Child Accidents and Associated Risk Factors in a Brazilian Squatter Settlement." *Health Policy and Planning* 4(2):162-67.
- Rice, D. P., E. J. MacKenzie, and others. 1989. *Cost of Injury in the United States: A Report to Congress*. Institute for Health and Aging, University of California and Injury Prevention Center (San Francisco) and Johns Hopkins University.
- Robertson, Leon S. 1981. "Automobile Safety Regulations and Death Reductions in the States." *American Journal of Public Health* 71:818-22.
- . 1983. *Injuries: Causes, Control Strategies, and Public Policy*. Lexington, Mass.: Lexington Books.
- . 1984. "Automobile Safety Regulation: Rebuttal and New Data." *American Journal of Public Health* 74:1390-94.
- . 1990. "Car Design and the Risk of Pedestrian Deaths." *American Journal of Public Health* 80:609-10.
- . 1992. *Injury Epidemiology*. New York: Oxford University Press.
- Robertson, L. S., A. B. Kelley, B. O'Neill, C. W. Wixom, R. S. Eiswirth, W. Haddon, Jr. 1974. "A Controlled Study of the Effect of Television Messages on Safety Belt Use." *American Journal of Public Health* 64:1071-80.
- Rosenberg, M. L., R. J. Gelles, P. C. Hollinger, M. A. Zahn, and others. 1987. "Violence: Homicide, Assault, and Suicide." *American Journal of Preventive Medicine* 3(5 supplement):164-78.
- Ryan, G. Anthony. 1990. Assignment report, for Prevention and Control of Road Traffic Accidents Project. (WFP)MNH/CP/APR/001-E. World Health Organization, Geneva.
- SAE (Society of Automotive Engineers). 1984. *Advances in Belt Restraint Systems: Design, Performance, and Usage*. Special Publication P-141. Warrendale, PA.
- Saleh, S., S. Gadalla, J. A. Fortney, S. M. Rogers, and D. M. Potts. 1986. "Accidental Burn Deaths to Egyptian Women of Reproductive Age." *Burns* 12:241-45.
- Salgado, M. S., and S. M. Clombage. 1988. "Analysis of Fatalities in Road Accidents." *Forensic Science International* 36(1/2):91-96.
- Sarn, J. 1989. "International Donor Aid to EMS Development." Paper presented at the International Conference on Emergency Health Care Development, Crystal City, Va.
- Schelp, Lothar. 1987. "Community Intervention and Changes in Accident Pattern in a Rural Swedish Municipality." *Health Promotion* 2(2):109-25.
- Schwab, Larry. 1990. "Blindness from Trauma in Developing Nations." *International Ophthalmology Clinics* 30(1):28-29.
- Selya, R. M. 1980. "Deaths Due To Accidents in Taiwan: A Possible Indicator of Development." *Social Science and Medicine* 14D:361-67.
- Shanmugasundaram, T. K. 1988. "The Care of SCI Patients in the Developing Nations—Can We Stem the Rot?" *Paraplegia* 26(1):10-11.
- Shepherd, A. 1980. "Road Traffic Accidents: A View from the Highlands." *Papua New Guinea Medical Journal* 23:57-58.
- Shih, J. H., Z. Q. Wu, Y. L. Wang, Y. X. Zhang, S. Z. Xue, and X. Q. Gu. 1985. "Prevention of Acute Parathion and Demeton Poisoning in Farmers around Shanghai." *Scandinavian Journal of Workers' and Environmental Health* 11 (Supplement 4):49-54.
- Silva, J. F. 1978. "A Comparative Study of Road Traffic Accidents in West Malaysia." *Annals of the Royal College of Surgery of England* 60:457-63.
- Sinha, R. N. 1984. "Burns in Tropical Countries." *Clinics in Plastic Surgery* 1(1):121-27.
- Sinha, S. N., S. K. Sengupta, and R. C. Purohit. 1981. "A Five Year Review of Deaths Following Trauma." *Papua New Guinea Medical Journal* 24: 222-28.
- Sloan, J. H., A. L. Kellerman, D. T. Reay, J. A. Ferris, T. Koepsell, F. P. Rivara, C. Rice, L. Gray, and J. LoGerfo. 1988. "Handgun Regulations, Crime, Assaults, and Homicide: A Tale of Two Cities." *New England Journal of Medicine* 319:1256-62.
- Smith, G. S., and P. G. Barss. 1986. "Beyond the Motor Vehicle: The Importance of Other Unintentional Injuries as a Preventable Cause of Ill Health in Developing Countries." Paper presented at Risks Old and New: A Global Consultation on Health, April 27-May 1, Emory University, Atlanta, Ga.
- . 1991. "Unintentional Injuries in Developing Countries: The Epidemiology of a Neglected Problem." *Epidemiologic Reviews* 13:228-66.
- Smith, G. S., and H. Falk. 1987. "Unintentional Injuries." *American Journal of Preventive Medicine* 5(supplement):143-63.
- Smith, G. S., and J. F. Kraus. 1988. "Alcohol and Residential, Recreational, and Occupational Injuries: A Review of the Epidemiologic Evidence." *Annual Review of Public Health* 9:99-121.
- Smith, R. S. 1974. "The Feasibility of an Injury Tax Approach to Safety." *Law and Contemporary Problems* 38(4):730-44.

- Sonnen, A. E. H. 1980. "Epilepsy and Swimming." In *Epilepsy: A Clinical and Experimental Research*. Monographs in Neural Science 42. Basel: Karger.
- Sood, S. 1988. "Survey of Factors Influencing Injury among Riders Involved in Motorized Two-Wheeler Accidents in India: A Prospective Study of 302 Cases." *Journal of Trauma* 28(4):530-34.
- Sowemimo, G. O. 1983. "Burn Injuries in Lagos." *Burns Including Thermal Injuries* 9(4):280-83.
- Sri Lanka Psychiatric Association. 1982. *National Plan on Mental Health for Sri Lanka*.
- Subianto, D. B., L. R. Tumada, and S. S. Margono. 1978. "Burns and Epileptic Fits Associated with Cysticercosis in Mountain People of Irian Jaya." *Tropical Geography and Medicine* 30(3):275-78.
- Taket, A. 1986. "Accident Mortality in Children, Adolescents, and Young Adults." *World Health Statistical Quarterly* 39:232-56.
- Technical Study Group. 1987. *Toward a Less Fire-Prone Cigarette: Final Report of the Technical Study Group on Cigarette and Little Cigar Fire Safety*. U.S. Consumer Product Safety Commission, Washington, D.C.
- Teret, S. P., and M. Jacobs. 1989. "Prevention and Torts: The Role of Litigation in Injury Control." *Law, Medicine, and Health Care* 17:17-22.
- Thapa, N. B. 1984. "Injury Prevention in Nepal." *Souvenir Napas Journal* 3(1):136-39.
- Trunkey, D. D. 1983. "Trauma." *Scientific American* 249:28-36.
- UNICEF (United Nations Children's Fund). 1989. *State of the World's Children*. New York: Oxford University Press.
- Waller, J. A. 1985. *Injury Control: A Guide to the Causes and Prevention of Trauma*. Lexington, Mass.: D. C. Heath.
- Warner, K. E. 1990. "Tobacco Taxation as Health Policy in the Third World." *American Journal of Public Health* 80:529-31.
- Wechsler, H., E. H. Kasey, D. Thum, H. W. Demone, Jr. 1969. "Alcohol Level and Home Accidents." *Public Health Reports* 84:1043-50.
- Weddell, J. M., and A. McDougall. 1981. "Road Traffic Injuries in Sharjah." *International Journal of Epidemiology* 10:155-59.
- Werner, David. 1987. *Disabled Village Children*. Palo Alto, Calif.: Hesperian Foundation.
- . 1989. "Health for No One by the Year 2000: The High Cost of Placing 'National Security' before Global Justice." Paper presented to the 16th Annual International Health Conference, National Council on International Health, June, Arlington, Va.
- West, J. G., M. J. Williams, and D. D. Trunkey. 1988. "Trauma Systems: Current Status, Future Challenges." *JAMA* 259:3597-600.
- WHO (World Health Organization). 1952. Technical Report 48. Geneva.
- . 1977. *International Classification of Diseases. Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death*. 9th rev. Geneva.
- . 1986. *Report of the Second Global Liaison Meeting on Accident and Injury Prevention*. IPR/APR 218 m21A. Geneva.
- . 1987a. *Accident and Injury Prevention at the Primary Health Care Level*. IPR/APR 218 H. Inter-Regional Consultation on Research Development for Injury Prevention, Pattaya, Thailand.
- . 1987b. *Report of the Asian Seminar on Road Safety*. IPR/APR 218 G. WHO Regional Office for Europe, Geneva.
- . 1988. *Global Medium-Term Programme: Accident Prevention*. APR/MTF/88.1. Geneva.
- . 1989a. "Manifesto for Safe Communities: Safety—A Universal Concern and Responsibility for All." Resolution adopted at the First World Conference on Accident and Injury Prevention, September 20, Stockholm.
- . 1989b. *New Approaches to Improve Road Safety*. Technical Report 781. Geneva.
- . 1989c. *Research Development for Accident and Injury Prevention*. IPR/APR 216 m31R, 8923E. Geneva.
- Wintemute, G. J., S. P. Baker, D. Mohan, S. P. Teret, and C. J. Romer, eds. 1985. *Principles for Injury Prevention in Developing Countries*. IPR/ADR 217-40. World Health Organization, Geneva.
- Wong, M. K., C. F. Chen, and I. N. Lien. 1981. "Evaluation of the Results of a Rehabilitation for Spinal Cord Injury over a Recent Ten Year Period." *Journal of the Formosan Medical Association* 80:433-41.
- Wyatt, G. B. 1980. "The Epidemiology of Road Accidents in Papua New Guinea." *Papua New Guinea Medical Journal* 23:60-65.
- Xue, Shou-Zhen. 1987. "Health Effects of Pesticides: A Review of Epidemiologic Research from the Perspective of Developing Nations." *American Journal of Industrial Medicine* 12:269-79.
- Zador, P. 1983. "How Effective are Daytime Motorcycle Headlight Use Laws?" *American Journal of Public Health* 73:808-10.

Source: Dean T. Jamison, W. Henry Mosley, Anthony R. Measham, and Jose Luis Bobadilla (eds.). *Disease Control Priorities in Developing Countries*. New York: Oxford University Press for the World Bank. 1993.